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THEATER SECRETS.

WHEN Fontana, the Nymph of Palermo, descends into the sea, without moving a limb, apparently something supernatural has happened; but when we know that her downward course is carefully guided by two strong men, all traces of the wondèr disappear.

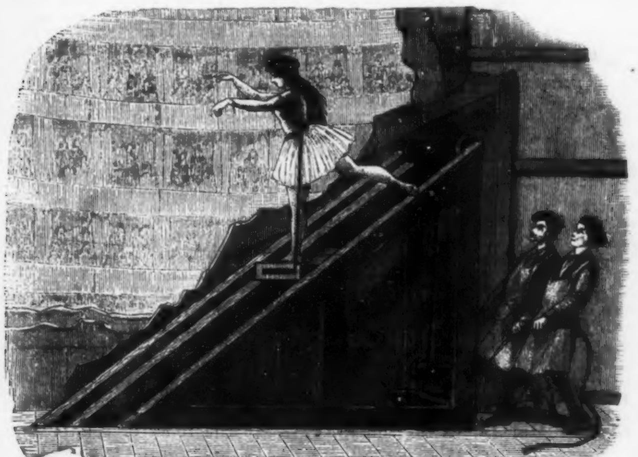
The up and down movements of Willis in the Gisella Ballet are caused by a common seasaw. In the Sicilian Vespers, the secret of the wonderful flower basket, which contains such a remarkably large number of living "flowers," is easily explained. These "flowers" remain quietly in their dressing rooms until the proper moment for them to appear.

"Farewell, my swan!" sings Lohengrin, and strokes the head and neck of his darling tenderly. It sometimes happens that the operator behind the scenes maliciously pulls the head of the swan away from the singer, whose caresses are apparently lost on his favorite.

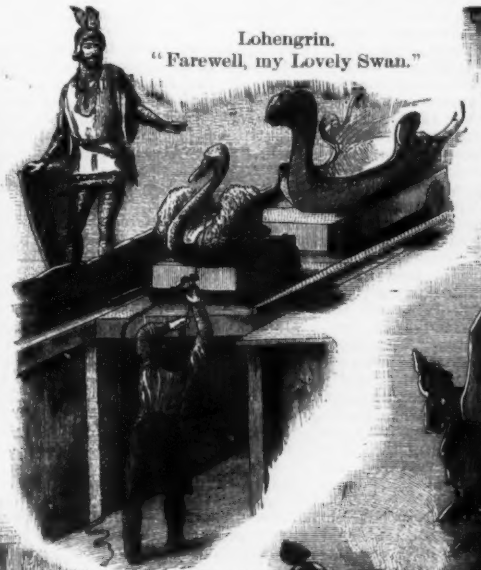
If the steps from the stage, in "Der Freischutz," could be seen by the audience, how absurd it would sound when Max cries "Woe is me, I cannot get down!" and Caspar calls from the valley, "Coward, and yet you can climb like a chamois!"

When the boys in the lion's skin disagree and try to go in different directions, a peculiar spectacle is presented to the audience.

The movement of the scenery is clearly shown in the sketch, and needs no further explanation.



Fontana descends into the Sea.



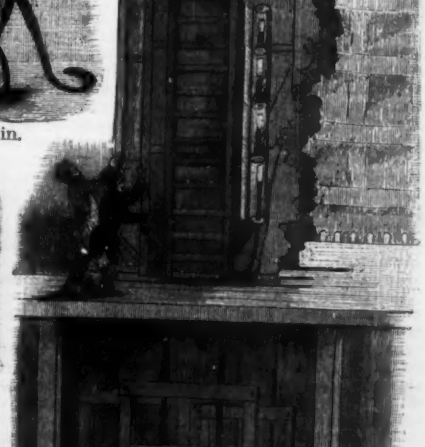
Lohengrin. "Farewell, my Lovely Swan."

Max: "I cannot get down."—Freischutz.

The Floating Willis (ballet).

In the Lion's Skin.

Sicilian Vespers.



Moving Scenes.

THEATER SECRETS.

A FRENCH VIEW OF AMERICANS.

IT is well known, says a French contemporary, that the Americans are a very practical people even in their religion. One of them has just invented a burglar-proof safe, which when tampered with suddenly extends a powerful pair of tongs or grippers, which seize the malefactor and hold him in firm embrace. There is nothing extraordinarily new in all this, but there is something further. Nearly always safes that are likely to be visited by burglars are in buildings unoccupied during the night, and it is only the next morning that the captured robber is carefully released from the trap, to be duly imprisoned. This is, of course, time lost, which the religious inventor desires to utilize. He has, therefore, had prepared by an eloquent preacher a very long and remarkably forcible sermon, in which the rights of property, the disgrace of stealing, and the dangers attending it, both in this world and the next, are set forth in the most touching language. This sermon, stored in a phonograph, is set off at the same moment that the pincers operate, and the homily is rolled out in the ears of the "patient." The monotonous, nasal tone peculiar to the phonograph renders the illusion perfect; the unfortunate robber believes he hears the voice of the preacher himself, and in the morning, when the police arrive, they find him thoroughly subdued and repentant.

SIBLEY COLLEGE LECTURES.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

I. Dr. R. W. RAYMOND.—"Machinery and Education."

THE following, one of the regular winter course of Sibley College (Cornell University) lectures, was given on Friday, November 20, before the assembled societies of engineers, by Dr. Rossiter W. Raymond, of New York, Past President of the Institute of Mining Engineers. The general treatment of the subject had been previously followed by the lecturer on other occasions; but the address was wholly extemporaneous and the matter largely novel.

The subject was "Machinery and Education; a Study in Evolution." The following is a report, tolerably complete, of the lecture:

Gentlemen: Sibley College, the school of mechanical engineering of Cornell University, is one of those institutions devoted to the special training of a certain class of young men, in which the attempt is being made to solve one of the most important and pressing of the educational problems of the age. It illustrates the present status of the experimental development of a phase of this work which is of exceeding interest and importance. It is evident, also, that the endeavor is meeting with a gratifying degree of success; but it must be recognized that any amount of success can hardly be considered as a solution of the whole problem of education. This may prove itself to be a good without being the very best method; or it may be the best, with, yet, an alternative equally good. It may be the best to-day, and yet not the best to-morrow, or for another generation. It is entirely improbable that we shall ever be able to say that our system of education is perfect, finished, beyond improvement in theory or in practice. Our schools will never become machines receiving the raw material at one end and turning out the finished product, perfect and incapable of further improvement, at the other. Methods must be adapted, constantly, to changing conditions, for the purpose of securing adaptation of the subject of such methods to the environment. We are to suit our means and methods to the needs of a most complex organism, in the midst of changes illustrating a most singularly complicated, but definite, evolution. Precisely as all the progress in the animal and vegetable worlds is the continual adaptation of each organism to its surroundings, constantly striving for complete adjustment to the existing conditions—conditions themselves continually changing—so the methods of action of the human mind are as continually being modified to meet the exigencies coming with a varying existence, never fully attaining the object, but always approaching it. The one result sought by all, whether animal, vegetable, or the human body and soul life, is fitness. It is for us to ask: Fitness for what?

To all of us who believe that this life is but the beginning of a greater, a higher, a broader, and eternal life, that it is but the period of initiation into an existence having far more important relations, it is evident that what is essentially, imperatively, required is fitness for that eternal life. But it is certan that fitness for this life is the means of preparation for that higher existence. We may fairly study the problem of education, therefore, in its relations to the present life without necessarily forgetting or undervaluing the moral and spiritual aspects, so prominent when viewed from the other side.

It is the object of my remarks, this afternoon, to call your attention especially to some interesting and perhaps important analogies between the evolution illustrated in the growth of natural forms in the visible world and the development and adaptation of the human mind and human thought, as modified by environment and by special education, in the midst of its controlling external conditions.

The idea that it is possible to trace a process of evolution in machinery analogous to that observed in the natural world may, at first thought, seem absurd. It may be urged that there is no connection by heredity between one form and another; that the boat is not the child of the raft or the parent of the ship; that no such relations exist as are traced in the theories and the succession of phenomena upon which are founded the accepted hypotheses of Darwin or Spencer or Haeckel. But we are not so to consider machinery. It does not stand by itself as an independent line of related forms; it is simply a part of its creator, man. To trace its history is to trace the history of the intellectual evolution of the race. No other history is so complete, so reliable, so instructive. Looking at the history of literature, we see that its recognized masterpieces are ancient. Our poets do not surpass David or Homer; our philosophers sit at the feet of Plato. Art still gazes at Raphael. Music still listens to Beethoven. That the race has really advanced can best be seen by the study of its material constructions. It is here that we find much to illustrate an evolution similar to that which we trace in the natural world. We find many examples of the evolution of recent advanced forms by descent and modification. These two principles are the basis of all such growth: the principle of heredity and the principle of variation by adaptation. The plant-forms tend to preserve, on the one hand, their family characteristics as exhibited in the earlier generations, while they, at the same time, have an evident power of adaptation, more and more perfectly, to surrounding conditions. So that all natural forms continually show a tendency of growth in the direction of specialization. From the first and lowest forms, the animal world progresses toward the highest by a similar change resulting from the struggle between two principles. From the simpler forms, the creatures having but a mouth and a stomach, evolution leads up to the higher forms, creatures in which those essential organs become tributary to a hundred other organs, each having its special function.

The progress of human industry is illustrated in the history of the development of engineering and in the evolution of machinery. The subject of our investigation is not the machine, however, but the machine as an organ of the man. It is man and his machine which forms the object of our study. Thus the savage has a single implement, which he applies to a hundred purposes. It may be a stick, which is at once, hoe, rake, and plow; but the instrument of the civilized man has been adapted to one use, and but one. His hoe is only a hoe; his rake can only perform the office of a rake; and his plow can only plow, and each of the several forms of plow, even, is adapted to a particular kind of plowing. In the development of animal forms, the earlier grow out of the later by successive differentiations and accretions; the higher forms do not lose mouth or stomach, but include those first of all organs in the most complicated organisms. This is not so with machines; but it is so with man plus his machinery. Man is to be considered as including his tools and his machines. The savage in his earliest stage is simply a man; at the next step, it is the man with a stone; then we see a man with his spear, with his stone and spear and knife, with tool after tool successively added, until the civilized man appears, monarch of the world, a giant condensed into six feet. He has surrounded himself with amplified members. The hammer is an extension of the arm holding the stone; the knife and his other cutting tools are but artificial teeth and nails; the lever, the wheel, the wedge, the screw, the engine and its gearing, the electric wire and its machinery, are all typified by the primitive forms of the human body.

It is not the fact that evolution, as has been said, stopped with the introduction of man upon the globe; the most remarkable of all the remarkable, the wonderful, stages of evolution is the evolution progressing in the development of man himself. It is the development of man, with his organs and self-constructed amplifications of those organs, that constitutes the most astonishing of all the products of this wonderful process. It is man plus machinery, whose vision comprehends alike planet and distant star and the minutest animalcule; who hears the whispers of a world; who listens to the past and speaks to the future; whose feet span continents and seas; whose hands rend the mountains, divert the rivers from their ancient beds, make the air resound with the din of countless industries, and who shakes the ground with the thunder of battle. It is not the printing press, the steam engine, the telegraph, gunpowder, or dynamite; it is man who does all this.

Prof. Reuleaux, in an address recently delivered before the Industrial Association of Lower Austria, and excellently translated by Mr. Wheaton B. Kunhardt, in the *Quarterly Journal of the School of Mines*, of New York, makes an interesting comparison between the nations which have built their civilization upon the use of machinery and those which remain relatively without this potent factor of progress. To express what I have called man plus machinery, he coins a new and somewhat amusing word. In days when the skillful employment of the powers of nature was believed to partake of the supernatural, the Greeks applied to a mechanical system the word *manganon* indicating its alliance with the occult acts of magic. In later ages, the same word designated a sort of catapult employed in war; and later still, when the catapult had gone out of fashion, and a machine which looks something like it was introduced for the ironing of linen, the old warlike name was transferred to the engine of peace, and passed with this meaning into all the languages of modern Europe, appearing in our English tongue as the mangle. This is the word which Prof. Reuleaux has selected to express the general idea of machinery. He divides the world into the *manganistic* and the *naturistic* nations, calling the former also Atlanticists, since they are the nations which inhabit the shores of the Atlantic (including in that term the Mediterranean and the North and Baltic Seas). As he proceeds to show, the manganistic nations—those which characteristically use "mangles"—comprise only 250 million out of the 1,500 million of the world's inhabitants; but they burn for mechanical purposes probably 400 million tons of coal per annum. This represents in round numbers about 90 million horse-power per day of 12 hours for 300 working days, or (estimating a horse-power as equal to the power of six men) 540 million man-power daily. Now, if we assume that the labor of the 1,250 million naturists amounts to the continuous maximum effort of one-tenth their number, exerted through 12 hours daily for 300 days, we shall be giving them what must be considered, in the light of our knowledge of their general habits, a liberal allowance. Hence they may be assumed to generate 125 million man-power daily in industrial avocations. But the manganists work hard besides; and if we allow as much in proportion for their manual labor as for that of the naturists, we shall be doing them less than justice. Including 25 million man-power for this item, we have a total of 565 million man-power daily. When it is considered that we have not taken into account the use of other fuel than coal, or the employment of wind-power by ships and windmills, or of water power in a hundred ways, it must be admitted that our estimate is moderate. Yet it shows that one-sixth of mankind employing machinery exerts daily 4·5 times as much force as the other five-sixths; in a word, that one civilized man—one man plus machinery—is worth 22 barbarians!

This is more than a mathematical joke. It explains the material, political, and moral supremacy of the civilized nations. It accounts for those comforts and facilities which, lightening the crushing burden of life, permit men to enjoy, to aspire, to advance. It shows how man, thus disenthralled and stimulated, can lift himself toward God.

But to return to our line of analogy: another element of promoting the evolution of machinery is competition. It is this which corresponds to the "struggle for survival" of the Darwinian hypothesis. It is here even more effective than there. The evolution and modification of recent forms of life has demanded ages and ages; the production of the modern forms of machinery occurs in a generation. With the former we can see the struggle, we can believe readily the survival of the fittest; but the evolution of new species by the accumulation of peculiarities, transmitted to successive generations, and, by gradual accretion, of protective distinguishing traits, we can only infer. But machines are the expressions of thought which pass through their successive generations in hours, in minutes, in seconds, rather than years or ages, and new forms rapidly succeed each other, each the best at the time, but each displaced and superseded by a later rival.

At the bottom, the causes of the maintenance and improvement of the representatives of either class are substantially the same. The organic forms are struggling for life, to secure food for sustenance, and to perpetuate the species by the production and rearing of offspring. The object of each distinguishing peculiarity is the better adaptation of the organism to these purposes. So with man: If we consider the creature with his development in the machinery which is a part of him, we will see that it is not the mere animal, whether cultivated or savage, but the multiplied, the many sided, the amplified, man which must be perpetuated, preserved, and improved, rendered fitter for his place in the universe. Each new generation receives from the preceding all that it can supply, and adds its accumulations of knowledge, of power, and of aspiration. The greater amount of learning and experience demanded in civilized life compels economy of labor, and thus the production of machinery. The causes of continuance, of success, are the same as with the organism; they survive because they contribute to the fitting of the race to its environment, in other words, "because they pay," as the engineer would say.

It is not the fact that the machine which is theoretically the best is really so—the theory may be imperfect; the conditions to be met may be of less pressing importance than others conflicting with them. A fuel-saving attachment to a steam engine is not wanted in a region where fuel has no market value; it would not be prized very highly by a Saginaw lumber man or a blast furnace manager in Ohio.

I shall never forget what a great inventor once said to me, when I brought to him some crude, youthful notion of my own: "The most important thing about invention, my boy, is to know what needs to be invented; we do not want an ingenious and elaborate machine to pull a cork." So it is evident that the conditions which do not strongly affect the species struggling for life are not effective in producing a permanent change. Color is not important in protecting domestic as in the preservation of wild animals, and hence the variety of color seen among the former and the uniformity characterizing the latter. Even the existence of the so-called "remanent" organs of animals has a counterpart in the machine. The zebra markings always seen in the line down the back of the horse, and more plainly in the coloring of the ass, the rudimentary and superfluous organs in man, are simply so many traditions of an earlier life. In the same way we find in the present "standard" gauge of railways a remanent characteristic coming from the common gauges of wagon wheels before the days of the locomotive. Brunel insisted that 7 feet, the gauge of his Great Western Railway, was certainly the coming standard, while Fairlie has proved to his own satisfaction and that of his followers that 3 feet is too great for economy. But the world follows the old, since it has no sufficient compulsory influence to do otherwise. The inconvenient and uncomfortable coupés of the European railways are the relics of the times of the stage coach; the two buttons on the back of the coat, adorning the garments of every masculine dandy, are preserved from the costumes of chivalrous days, when the wearing of the sword was at once a necessary protection and a testimony of the knightly standing of the man; later, the skirts were cut away; the sword was laid aside; but the buttons were left stranded by the wave of reform, and remain, like forsaken clams at high-water mark, to show what was once the margin of the tide.

Two great fundamental laws control the evolution of organic forms: the law of heredity and the law of variation. In the production of the fruits of the inventive faculty, two laws are also involved: the law of imitation and the law of invention. Thus the useful variations only are preserved in either case, although a thousand other forms may have come into ephemeral existence. Similar resemblance is seen in other directions. The embryo of the animal has been found to pass through the earlier types in its development toward maturity, passing through stages, in each of which it resembles an ancestral form, rapidly and by steady gradation, unerringly toward the highest contemporary form. So each new generation of the human mind passes through a similar succession of developments. Each infant travels through the whole road previously laid out by the race. Inherited habit is efficient in the lower animals, every individual receiving from his ancestry more or less of his early proclivities. We are not as well provided in this direction as the lower animals, probably in consequence of the greater effect of training. The child stretches out its arms toward the moon as if it were an orange near at hand, and requires experience to teach it the true relation of distance; but the chicken, just hatched, will take aim at a fly and strike it every time. But it is just that operation which the earlier generations of chickens have been performing for an indefinite period, and it has become an inherited habit, such as we call instinct. This principle operates, fortunately for us, in the mental and moral spheres of man's life. The education which one generation receives assists the next in more easily acquiring knowledge. Otherwise, we should have a labor before us more trying than that of Sisyphus, a labor growing in magnitude and difficulty with each attempt at its performance. Science, acting through inherited training, does what natural growth and nutrition is seen to do for the embryo. It takes it easily and rapidly through the initial stages of individual progress, and, in a few short months, takes it up to the starting point for a new life which is actually the culmination of ages of descent.

As nature produces first innumerable varieties, and then develops these by assimilation into species or groups, so every science has first its period of complication, then that of simplicity. As methods become perfected and formulas generalized, knowledge of facts becomes easier of attainment. Thus the elements of a complete and harmonious culture are being extended and yet rendered easier of acquirement. It is claimed that we should always "follow nature" in education; but the phrase is vague, and may be misleading. It must not, we may be sure, be interpreted to mean that students must be taught all of arithmetic, with its clumsy rules and cumbersome methods, before learning the clear, sure, and simple methods of algebra. It is not true that, because the race has for generations floundered on in this way, it must continue to do so; to study grammar after grammar, in the acquisition of the languages, before learning the science of universal grammer, though the last is of recent date. It would be as sensible to assert that the gardener must imitate nature by permitting his plants to be subject to all the malign influences of a slow and fitful spring, and cease to aid their growth by sheltering and warm-

ing them, or to wait for nature to develop the pippin out of the crab apple, rather than graft. Nature has once gone through that process, and has found the operation so tedious that she will be glad of a chance to aid the gardener and relieve herself by going, under his guidance, straight to the desired end by the quicker route.

In this evolution of man with his machinery are to be observed some phenomena which are likely to furnish excellent lessons to the educator. One of these is the reaction, now to be perceived in its beginnings, against the consolidation of industrial organizations, by the introduction of small motors and machines, which enable the individual to compete with the incorporated organization. The growth of these great organizations has seemed to threaten the life of the minor industries and the rights of the individual. It led us to discuss the rights of labor as if distinct from the rights of man, and to ask what means could be adopted to preserve those rights. Co-operation, association in various forms, by the association of many men, each having a little capital, was looked upon as the remedy for the centralization of power and capital held by stronger hands. The limit of this power may already have been reached, and a reaction has already commenced in the realm of mechanics which promises, I think, to be more effective and more powerful than all agitation and all legislation. The introduction of the small motor, the air engine, the gas engine perhaps still more effectively, is proving to be the agent bringing about this change. There are already, it is said, 5,000 small gas engines in operation in Paris alone, supporting the smaller manufacturers in competition with factories, the individual competing with the organization. The electric light may thus be made an effective weapon in competition with the gas monopolies; private steam carriages may yet control the charges of railways; and who knows but that a later generation may travel without horses in conveyances gliding above the surface of the ground, clearing fences and houses, lifted by buoyancy of some form of balloon? Small motors will undoubtedly do much for us in directions which we, as yet, have not imagined.

So we see two characteristics of evolution in operation: the reversion to an ancestral type and the return, in the organization of the race, to the family rather than the community, as the unit of life of the species. Thus all these facts bear upon the science of education. We seek fitness—fitness for the age and the environment; fitness for a time in which the community and the individual are more powerful than ever before; in which the great prizes are won, and great deeds accomplished, by only those men who are competent to command, to plan, to create. Such powers can only be gained by familiarity with facts, by mastery of principles. It is only thus that the people of our time and later years can become capable of using more and more machinery, of working machine and brain efficiently without being destroyed by the attempt to meet the growing demands of life. And how shall such fitness be gained? Obviously, in every line of life, by special training, a training in which the student must pass swiftly, but effectively, through all the stages separating the tyro from the expert, becoming finally the critic, the designer, the director. Obviously, too, these later heights are only to be fully attained through the operation of a broader culture. The man, the fellow man, must be the foundation of the specialist or he can never be other than a subordinate. He must have knowledge of men and influence with men, influence coming of knowledge and sympathy with them. Influence is what gives power, the ultimate and crowning form of power. Eminence cannot now be reached by treading down the crowd and by climbing over them; the crowd itself will lift up and sustain its recognized superior, and in a newer and better way the man of knowledge, skill, and sympathy will stand above his fellows.

It is asked, What shall be the *curriculum* of modern education? I do not like the word *curriculum*. You are aware that it means the circus ring, in which the chariot races took place. It seems to carry the idea of a set of young men wildly rushing around a four years' course, eager to get out at the door by which they went in, and joyfully exclaiming, as they attain their graduation, "Now we are done!" Ah! The track is longer than that; the race means far more than that. A spur will not win it; no narrow outfit will suffice for it. "What should we study?" Keep yourselves fully up to that sentiment at the expression of which a Roman theater awakened thunders of applause, thrilling the world through the succeeding centuries: "I am a man, and I count nothing that pertains to man indifferent to me." Forget not how vastly broader is the life of man than when those words were spoken. Privileges, opportunities, powers, of which no Roman emperor ever dreamed are offered to every one of us. Will you use them, or will you neglect and despise them?

You, gentlemen, students in Cornell University and workers in Sibley College, have a mission of unexampled importance to fulfill. It is for you to demonstrate that your education is the needed form to secure this fitness for the life coming to you upon your graduation. You are to show that the system under which you have been taught and trained is an efficient one; that these great buildings, with the grand corps of instructors who receive you here, the method and plan of which all illustrate their several parts, and show plainly to every visitor that nothing has been neglected that could inure to your benefit—that all this is the solution of the educational problem of our time. You are to prove that you are trained efficiently as to hand and as to head; that you can handle principles with the latter while wielding skillfully every tool with the former; that the skill of the hand is the higher and better, as the power of the brain is the nobler and the greater, for this combined training of both in one well-planned course of instruction. The hand should work the better for the aid of the guiding mind, and the mind work the more satisfactorily in the light of the practical experience. You are to prove still more that you are not the victims of a one-sided development; that a high professional training is not incompatible with broad culture, liberal views, generous, intelligent, and sympathetic interest in all that concerns the race; that you are capable of yourself attaining to and of appreciating in thers the highest ideal of character.

Thus you are to show that man plus machinery is the best product of the evolution of the centuries. Man including the machine, by its use, controlling it, creating it, learning through its operation, lifts himself to a loftier stature of individual growth, brings himself into closer communion and brotherhood with his fellow man, and fits himself to march on, with no lagging step, in the great procession rising to successive heights of victory, yonder and yonder—and *yonder!*

THE SIMS TORPEDO.

THE United States Government has adopted the Sims electrical fish torpedo as the main defense of the coast in the absence of proper batteries. When long range guns are procured, the two systems of defense will be combined.

The Government has bought and received five of these formidable engines of war, and has them stored at Willet's Point ready for instant service. The inventor, Mr. Sims, is building five or more of the huge, fish-like torpedoes under a contract with the War Department, and there is an unexpended appropriation for still seven more, which have been ordered. It is thought that 200 of these torpedoes will be sufficient to defend the coast against hostile fleets.

The torpedo is a cylindrical hull of copper, 1-16 of an inch thick. The ends are conical, and capped with steel. It is 28 feet long and 21 inches in diameter, and is made in four parts or sections, which are put together by means of lock joints. This copper hull is supported at a distance of about five feet under the water by a comparatively indestructible float, which is also made of copper, and is filled with packed cotton as a means of buoyancy. This float may be riddled with shot, and yet it will stay on the surface and support the submerged torpedo.

The float and the torpedo below it are connected together by steel stanchions. On the top of the float are two rods, or guides, surmounted by balls. These indicate to the operator where the torpedo is. They are hinged to the float, and are kept upright by springs. When the torpedo dives under or cuts through an obstruction, the springs allow the guide balls to lie in a socket, and to stand upright again when the obstruction is passed. The whole apparatus is provided with a steel propeller and rudder.

The torpedo may force its way through cables or similar obstructions by means of a sharp, strong blade which forms the prow, and which is set at an angle of 60 degrees, like the ram of an ironclad. This angle gives the knife great power in cutting, especially as the structure moves with great speed. Not only does this formidable prow serve this purpose, but when it strikes a spar or any other floating barrier, the slant makes the whole vessel dive, and its buoyancy enables it to rise on the other side, as it continues on its course toward the object of its attack.

The torpedo is extremely simple in its construction; the gross weight is about four thousand pounds, but, when taken apart, no single section weighs more than eight hundred pounds. Copper and brass are used almost exclusively, and this does away with the faults which steel torpedoes presented to the English Admiralty.

But the great feature of the torpedo which marks it out from all others is the fact that it is propelled, steered, and exploded by electricity. All other moving torpedoes contain in themselves the means of motion. As the space is small, the power is soon exhausted. Then the torpedo boat is useless for further maneuvering, although, so long as the power lasts, it can be steered from the shore by an attached cable. In the Sims torpedo, however, the power is generated by a dynamo electric machine on shore, and a continuous current of power can be kept up as long as is desired. This dynamo machine may be kept in the heart of the city if necessary, and the electricity conveyed to the shore by an underground wire, or the dynamo may be in a fort or on board of a war vessel. In fact, all men of war carry dynamo machines now.

In the bow of the submerged torpedo is placed a charge of 400 pounds of dynamite, which occupies the whole front section. The second section is an air-tight chamber. In the third section is coiled two miles of cable, weighing 700 pounds to the mile. It is payed out as the torpedo flashes through the water, and thus the propeller is not compelled to do the work of dragging a cable along the bed of the ocean or harbor. One end of the cable is connected with the propelling and steering apparatus in the fourth section of the hull, while the other end of the cable is connected on shore with the dynamo that furnishes the power, as well as with the keyboard of the operator. Inside of this cable are two wires—one for steering and the other for propelling. In the last section of the torpedo are two powerful magnets, which hold the rudder in the center when the hull is going on a straight course. When it is desirable to change the course, the operator moves a small lever on the keyboard, and the current passes into one magnet or the other, and the rudder is pulled about in the proper direction.

A rate of over eleven miles an hour has been attained in repeated Government tests, and the officers who have been experimenting for years with the torpedo say that it will be easy to get a still higher rate of speed with the same apparatus.

That the torpedoes cannot be destroyed by artillery fire from an enemy's ship has been thoroughly proved. The floats have been anchored in front of a fort and kept under a concentrated fire for hours, and still, riddled as they were, they floated and were ready for immediate service. Of course, no shot could hit the submerged torpedo, as the solid water would cause missiles to ricochet. While conducting the secret experiments at Willet's Point, Gen. Abbott tested the float under fire, and in his official report said:

"The float was anchored down in front of a 32 pounder howitzer. It was first fired five times at a range of 186 yards with double-shotted canister charges, each containing ninety-six balls. Five large holes were made by this firing, and the float was then towed about a mile by a steam launch at the rate of five miles an hour. On its return it had only lost 150 pounds of its 800 pounds buoyancy, and was perfectly serviceable for use in an attack."

Referring to the inability to obstruct the progress of the torpedo, the same engineer said: "The mast of a schooner, fifty-six feet long, was anchored by two 500 pound anchors, one at each end. The torpedo was driven against this obstruction twice at the rate of nine miles an hour, and the shock did no damage, but in both cases the torpedo dived under the log and continued its course uninjured. I regard these tests as sufficient to prove that the torpedo is quite safe against any artillery fire which it would encounter in actual service, and that no temporary protection in the shape of spars or logs moored around a vessel would be of any value against an attack. Probably a deep iron netting might check its course, but the explosion of its charge would be sure to open a route for a second torpedo following in the wake of the first. The charge when exploded would disrupt a modern double cellular iron warship at a range of thirty-one feet."

"As far as I can learn," said the inventor, Mr. Sims, "the purpose of the Government is to have the torpedoes stored at different forts on the coast in bomb-proof canals with gates. An operator and the machinery for generating the power are to be there, too. For naval offensive purposes it is proposed to have these torpedoes carried on board a man of war. By this arrangement the torpedo can be sent any distance at sea, and when it is wanted for action it may be released and set off at once under full speed. We claim for this torpedo, and we think that the tests bear us out, that it is the only one ever built that has the power outside itself."

One of the principal features in favor of the Sims torpedo is the steering power. During the tests at Willet's Point, it was made to describe a circle both ways and take a different course entirely, which showed how easily the boat could strike any desired object. On the 16th of last June, Gen. Abbott had a 57-foot spar anchored near Willet's Point. The torpedo was started from a quarter of a mile away. It struck the spar squarely in the middle, as was desired, and then dived under it. It was started out again, and the next time it struck the spar within a foot and a half of the same spot, after which it passed under the obstruction and continued on its course. The balls on the top of the float are designed to tell where the boat is to the operator who is running it. By keeping his eye on the balls he can always tell where the torpedo is, and direct it accordingly. As soon as the boat has reached the side of the vessel, the discharge is made by pressing a key on the board. All of the electricity which had been used to propel it, by a neat adjustment of relays passes into the explosive gelatine, and first discharges a small cartridge of fulminate of mercury, which in turn discharges the dynamite and produces the effect. If it is desired, the explosion can be caused by contact with the enemy's ship. In steering the torpedo, the operator does not need to be exposed to any danger. He may be down in a well one hundred feet deep, and an officer can shout "Right," "Left," "Stop her," "Explode," and so on. In the experiments at Willet's Point, sometimes the operator never raises his eyes from the keyboard.—*N. Y. World.*

THE STEAM PLOW.

A FIELD TRIAL NEAR CHICAGO.

ONE afternoon during the Fat Stock Show at Chicago, we went out into the country a few miles, in company with Prof. A. H. Sabin, of Vermont, and a few other gentlemen, to see a steam traction engine haul a gang of plows. Steam plowing is no new thing, as stationary engines with cables attached to the plows are used to considerable extent upon some of the large estates in England. But such plowing requires two engines, one stationed at each side of the field, the engines alternately drawing the plows across the land to be plowed. We were all the more interested in seeing the machine because two New England inventors of our personal acquaintance have expended large sums and no end of brain work in the attempt to construct a practical traction locomotive for heavy farm or road work.

A steam plow was also exhibited some years since, at a trial in one of our Western States, and took the first premium for best machine, but was never heard from again. The great difficulty has been to get an engine that could hold to the ground without sinking and getting stalled, thus requiring a team to haul it out. The machine exhibited at Chicago was invented by Mr. G. H. Edwards and C. H. Wood. Its one feature that promises to give it prominence above any similar effort consists in its broad track and the distribution of its own weight over a large surface, so that it can move safely over soft, miry ground, even where a team could not be driven.

To imagine the endless tread of a common horse power, with its wheels enlarged to four feet in diameter, would, perhaps, give one some idea of the appearance of the machine. The plank, as it comes to the ground in its revolutions, makes a firm bed to support the weight of the machine. This may be of any size desirable. Inside of the belt of planks is room for the water tank between the four large wheels over which the planks revolve, two of the wheels being drivers, and which lock into the cogs attached to the planks, so that slipping of the drivers is impossible.

The trial was made on soft, marshy land, which was as wet as water could make it, a portion plowed, and with water standing in the furrows. The machine moved off like a huge elephant, drawing its gang of plows behind it in a way that was a surprise to all, and moved with the same apparent ease over sod or the softest plowed ground. Being the first full-sized machine built, there is much about it that is crude and unfinished, the boiler in particular being too small for the other parts, and, not being protected from the weather by a jacket of any kind, is not economical of steam; but while the steam lasted the machine did all that any one could ask, and much more than the visitors had expected.

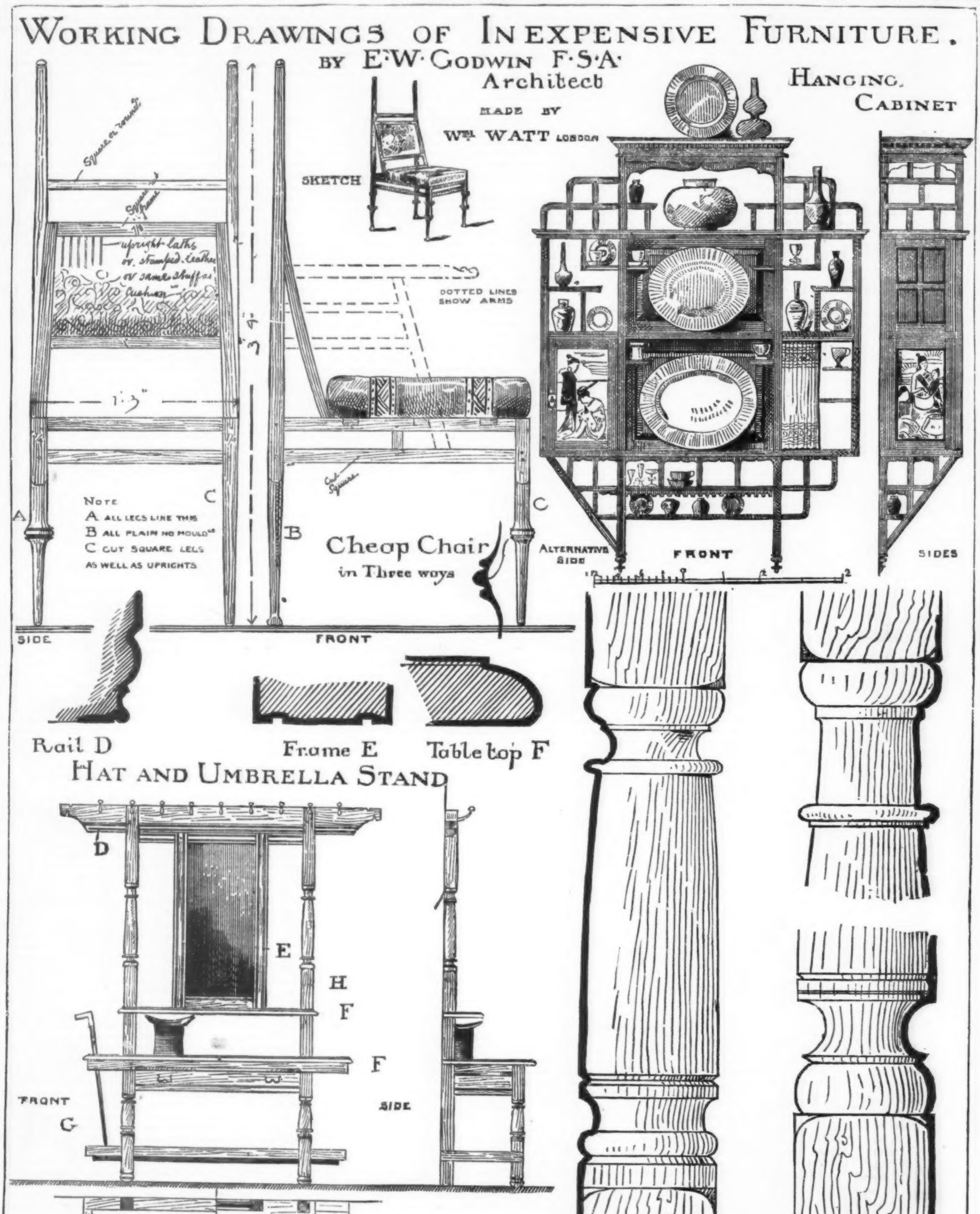
The inventors believe that the labor cost of growing wheat will be greatly reduced by their invention, the power being applicable in large fields to ditching, plowing, cultivating, seeding, harvesting and thrashing, and cleansing the grain, so that no horse power will be required, thus saving the cost of feeding teams in winter, and enabling the farmer to work many more hours per day, and get his work done in better season. The machine may also be used on the highway for shaping and hardening the surface of common country roads, rendering them more desirable for travel than broken stone roads. It is not claimed that a steam traction engine, however perfect, will very soon come into use on the small fields of our New England farms; but if it succeeds on the large Western plains, it will exert a material influence upon American agriculture.—*N. E. Farmer.*

WORKING DRAWINGS OF INEXPENSIVE FURNITURE.

By E. W. GODWIN, F.S.A.

THIS sheet of details furnishes the working drawings to scale of three useful and inexpensive pieces of furniture, designed by Mr. Edward W. Godwin, F.S.A., architect, and executed by the representatives of the late Mr. Wm. Watt, of Grafton street, W.C. Economic furniture, which also has the merit of being artistic, suitable, and useful, thereby being really adapted to the everyday requirements of ordinary people, must necessarily be always in demand, and therefore illustrations such as these, which we include in our number of plates to-day, certainly will be welcomed by many of our readers, especially those who know Mr. Godwin's designs, and have seen them beautifully carried out by Mr. Watt. The "cheap chair" details show how the same design may be made in three different ways, and also with arms if necessary. The seat can be stuffed or not, and the back is designed to be finished in the same material as the seat, or with upright laths, as may be wished to suit circumstances. The hanging cabinet is well adapted to the suitable display of works of art and ceramic ware, and is made in ebonized wood with panels fitted with Japanese designs, the whole being conceived somewhat in that manner or style of wood treatment.

The hat and umbrella stand is, of course, a very useful piece of furniture in most houses, and yet, generally speaking, it is one of the most ugly and inconvenient articles conceivable, vulgar in taste, and quite out of character with the objects for which it is supposed to exist. Mr. Godwin's design has nothing pretentious about it; on the contrary, it is as simple as can well be thought of, and yet how well it answers its purpose without being too big, and it has the merit of being simply what it was intended to be.—*Building News.*



INDUSTRIAL HEATING BY HYDROCARBURETS.

THE interest that attaches to the question of heating steam generators by hydrocarburets leads us to call attention to the burners that have been devised for this purpose by Mr. Favier.

It will be recalled that the first problem to be solved is that of bringing the liquid to a sufficient state of division to make its combustion almost instantaneously

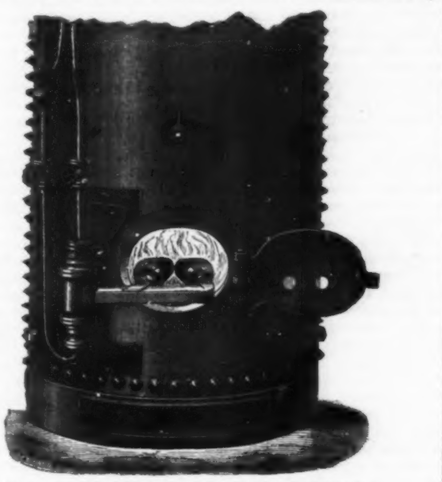
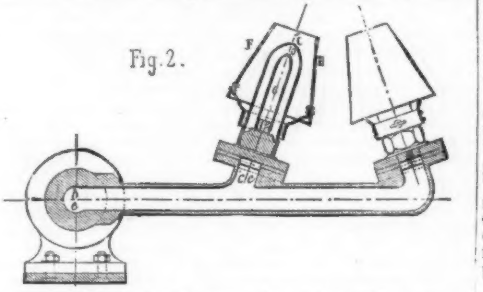


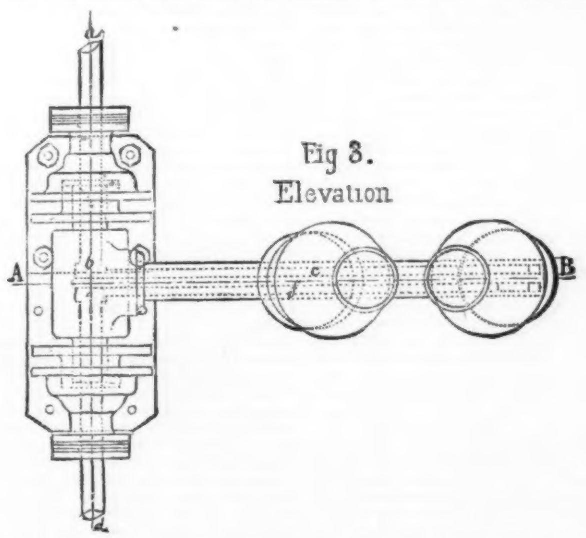
FIG. 1.—HYDROCARBURET BURNER.

complete. Afterward such combustion must proceed easily and remain stable, and for this purpose the vaporizing medium must have a sufficient temperature to render eminently inflammable such bodies as tar and the heavy oils, which, in their ordinary state, are with difficulty decomposable. With this object in view, Messrs. Favier and Helouis have constructed a vaporizer in which the dividing element, as well as the combustive, is air carried along by means of an injector, through the steam derived from the generator itself. This steam thus produces a double effect, which



is purely physical but very important, that is, a velocity of the current and a heating of the gas. The oil itself is previously heated during a portion of its travel from the reservoir to the orifice. To this effect, the oil, which has been pumped up into a reservoir, descends through the pipe, H (Fig. 1), follows the passage, H *a b c* (Figs. 2 and 3), and flows out at *o* with a velocity that is regulatable at will by means of a valve. It is here that it comes into contact with a current of air issuing from the injector that is regulatable by another valve, and that has taken the course, I *d f e* (Figs. 2 and 3).

The burner, G, then, will give passage to the vaporizing jet, whose temperature it suffices to raise once for all in order to cause the mixture to light and burn in a regular manner. The combustion is both rendered complete and kept up by the addition of a nozzle, F, called a "recuperator," which causes a strong draught around the flame, thus burning all the particles that tend to escape, and which concentrates the heat at its exit, thus securing to the mixture that occurs between *o* and *c* a constantly elevated temperature. Besides, the liquid in its very slow passage at *b c* reaches *o* strongly heated by the immediate vicinity of the conduit, *e f*. Any number whatever of burners may be combined by crossing their fires.



FIGS. 2 AND 3.—FAVIER & HELOUIS' VAPORIZER.—PLAN AND ELEVATION. (Scale 1-6.)

The whole (A B, Fig. 3) rotates around the vertical axis, *a d*, and the recuperators, F, are thus capable of passing into the apertures in the furnace door. The setting in operation, then, is of the simplest character. We begin by getting up a pressure in the ordinary way, then introduce the nozzles, and regulate the valves properly. The jet lights, and all that we have to do is to let the fire fall.

The substitution of hydrocarburets for coal is not the only application that Messrs. Favier and Helouis

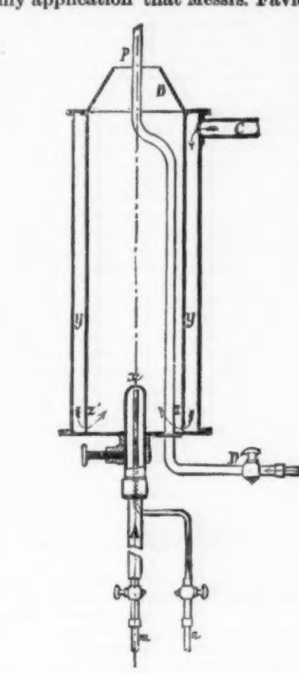


FIG. 4.—FAVIER & HELOUIS' BLOWPIPE.

have made of this principle. They have also devised a burner for lighting workshops, and which yields a luminous power of 35 carcels at a cost of 2 cents per hour, and also a blowpipe (Fig. 4) which offers a slightly different arrangement.

Combustion begins in the interior of a double jacketed cylinder, B', the vaporizer, A, being analogous to the preceding. The air from the exterior enters at C, becomes heated by circulating in the annular space, *y y*, and at *z z'* enters the chamber of the blowpipe. The flame escapes at *p*, where it meets with a new gaseous jet brought along at D. Independently of the combustible mixture, then, we find here a double draught of hot air. In this way there is obtained a flame of the highest temperature, that readily melts platinum.—*Le Genie Civil.*

VENTILATION.

IN modern life, with its enormous populations living under artificial conditions in towns and cities, the subject of ventilation, or the supply of sufficient pure air to each individual for the maintenance of health, has assumed, as it has become more generally understood, a vast and national importance. Its importance has been clearly demonstrated in many instances by a greatly diminished death-rate in places where overcrowding on space or in houses, formerly existent, has been remedied, and especially by a decrease in those diseases which are now generally recognized as preventable. Thus, since attention has been paid to the amount of cubic space and the supply of fresh air per head in barracks, the death-rate from phthisis or destructive diseases of the lungs in the army has fallen from 10 to 2 per 1,000; and typhus, formerly very prevalent in the jails of the country and in the crowded courts of our large cities, is now almost unknown in these situations. That there is still a vast amount of disease and death which could be prevented by a more general recognition of the absolute importance of a pure supply of fresh air under, all conditions, is a fact whose truth we recognize when we observe the numbers of scrofulous and rickety children and consumptive adults in our large centers of population. Many houses in the poorer parts of towns are absolutely debarred from obtaining fresh air and light by their surroundings. Built almost back to back, or fronting into narrow courts or passages closed at one or both ends, the sunlight never penetrates for months in the year, and a free current of air is an impossibility. Fortunately, the Legislature has recognized this evil, and the acts known as Sir Richard Cross' and Torrens' are intended to remedy such a state of things, and, where enforced, have succeeded in removing buildings which no structural alterations could improve. The erection of huge blocks of Industrial Dwellings, while affording vastly superior accommodation to the working classes, has not always secured efficient ventilation in these respects for certain of the tenements. We have seen instances of lofty blocks being built in such a way as to inclose a narrow and well-like court, in which the atmosphere is always stagnant, and from which the inner rooms derive all their light and air. Cottage buildings, with sufficient space in front and rear, are far preferable to lofty blocks placed in rows; but as they do not house the same number of people for the space occupied in crowded districts, where land is of such enormous value, the rents must necessarily be higher, the other accommodation being the same. The air of inclosed courts is often damp, and being stagnant allows suspended particles to fall and foul gases to accumulate in it, thus forming a suitable "nidus" for the growth and cultivation of such disease germs as are capable of existing in the air. It is true that the death-rates appearing in the reports of many of the Industrial Dwellings Companies are exceptionally low, but we must remember that a very large proportion of the working classes die in hospitals and not in their own houses, and such sources of error require to be very carefully eliminated. Of late years Artisans' Dwellings have been built on better principles, the experience derived from the sanitary failures of certain of the earlier erections having been taken to heart.

In the model by-laws of the Local Government Board, it is provided that no new street is to be less than 36 feet in width, that the frontage of any new building not standing in a street shall be at least 24 feet in width, and that there shall be an open space at the rear of any new building and belonging to it of an aggregate extent of 150 square feet, this space not to be in any case less than 10 feet wide, and if the height of the building exceed 35 feet, to be not less than 25 feet wide. If these rules could be always enforced in the cases of new buildings, an improvement would be gradually effected in and around towns in the poorer districts which is greatly needed.

From what has been said it will be seen that one of the principal points in any system of ventilation is that the air to be admitted into a building should be pure, and this can be insured if there is no impediment to the free circulation of currents of air on the outside. We come now to the second part of the subject, viz., the vitiation of air that is constantly going on in inhabited places from the respiration of men and animals, and from the combustion of gas, lamps, and candles, and the methods by which this vitiated air may be replaced by pure external air. The composition of the atmosphere is as follows in 1,000 parts: nitrogen, 790·0; oxygen, 209·6; carbonic acid gas, 0·4, and traces of ozone, ammonia with nitrous and sulphurous acids in the air of towns, and a variable amount of aqueous vapor. The air taken into the lungs of a human being has this composition, but that expired differs from it in the following particulars, the nitrogen remaining the same: the oxygen, which is the vital principle of air, is diminished 4 per cent., the carbonic acid is increased 4 per cent., the expired air is saturated with aqueous vapor and is heated nearly to the temperature of the body, 98° Fahr., and contains a small proportion of foul, decomposing organic matter, which exists partly in the form of vapor and partly as solid suspended matter (epithelial dust and scales). This organic matter, though small in amount, is the most injurious quality of expired air, giving to the atmosphere of an ill-ventilated room its close and disagreeable smell. Those who are familiar with the interiors of courts of law, with the pits and galleries of theaters, or with crowded buildings generally, are also familiar with the headaches, the lassitude, and the "malaise" produced by breathing for some hours a vitiated atmosphere. In analyses of such air, nearly ten times more carbonic acid has been found than is normally present in the outer air; and when this excess is known to mean a deficiency in oxygen and a corresponding excess in organic vaporous exhalations and suspended matter from the breath and bodies of the persons present, the foul nature of the atmosphere can be realized. The slow deterioration in health which results from the constant breathing of foul air is one of its most important results, and causes a predisposition to, and lessened power of, resistance to attacks of disease.

An adult man of average size takes in and breathes out, when at rest, about 30 cubic inches of air at each respiration, this act being performed about seventeen times in a minute, so that in one hour about 17 cubic feet of fresh air will have been vitiated to the extent of containing 4 per cent. of carbonic acid—that is to say, about 0·7 cubic foot. Such a man gives out when at rest, therefore, nearly 0·7 cubic foot carbonic acid gas per hour. Now, it has been found by Dr. De Chaumont, by chemical examination of a large number of samples of the air of inhabited rooms, that, the amount of carbonic acid in the outer air being 0·4 per 1,000, no close smell is perceived in the air of a room until the carbonic acid reaches 0·6 per 1,000, or exceeds by 0·2 per 1,000 that in the outer air, the close smell being always due to the foul organic matter in the impure air, which increases *pari passu* with, and is therefore estimated by, the amount of carbonic acid present. It has been assumed by De Chaumont, and experience has fully confirmed this assumption, that we can breathe with immunity air vitiated to this slight extent, but that we should not allow any greater vitiation. We may take it, therefore, that the object of ventilation is to supply sufficient pure air to a room to prevent the carbonic acid rising above 0·6 per 1,000, this quantity being known as the limit of respiratory impurity. It may be asked, Why should not the air of our rooms be as pure as the air outside? No doubt this would be desirable, were it not that it involves a continual renewal of the inner air by the outer, which means in cold weather an unceasing draught at an unbearable temperature. We

have seen that an ordinary adult man expires 0·7 cubic foot of carbonic acid in one hour when at rest; now, if such an individual were inclosed in an airtight chamber 10 feet high, 10 feet wide, and 10 feet long—that is to say, in a chamber containing 1,000 cubic feet space—in one hour the carbonic acid in this chamber would have had added to it 0·7 cubic foot of carbonic acid; the air originally contained 0·4 part of carbonic acid in 1,000 parts, so that after one hour it would contain $0·4+0·7=1·1$ parts of carbonic acid per 1,000, or $1·1-0·6=0·5$ part per 1,000 above the permissible limit for health. But if the subject of our experiment were inclosed in a room containing 3,500 cubic feet of space, in one hour the amount of carbonic acid would be only

$$\frac{3·5\times0·4+0·7}{3·5}=0·6$$ per 1,000, *i. e.*, the limit would have just been reached, and at the end of a second hour, to keep the carbonic acid to this limit, another 3,500 cubic feet of fresh air must have been allowed to enter the room. That is to say, an adult man requires when at rest 3,500 cubic feet of fresh air per hour; a woman or child requires proportionally less. For any individual above twelve years of age, we may take as an average the amount of carbonic acid expired per hour as 0·6 cubic foot, and for such an average individual 3,000 cubic feet of fresh air per hour is necessary. We can now appreciate the importance of cubic space, for if we are to supply 3,000 cubic feet of fresh air to every individual above twelve years in a room, and the amount of space, suppose, in a dormitory where ten persons sleep is only 300 cubic feet per head, then 30,000 cubic feet of fresh air must be supplied per hour, that is to say, the air of the dormitory must be completely changed ten times in this period, a proceeding which would cause in any but the very warmest weather a very disagreeable draught. But if the cubic space per head be 1,000 feet, then the air of the dormitory need be changed only three times per hour, and if such renewal be effected steadily and gradually, no draught need be felt. We may mention here that a certain amount of superficial or floor space is necessary for each individual, for if the height of the room is much over 12 feet, excess in this direction does not compensate for deficiency in the other dimensions, although the cubic space may be the same; thus it would not be the same thing to allow a man 50 square feet of floor space in a room 20 feet high as to allow him 100 square feet of floor space in a room 10 feet high, although the amount of space allotted to him in each case would be the same. It may be interesting here to mention that in common lodging houses under police regulations, 240 cubic feet of space are allotted to each adult, in barracks about 600 cubic feet, in general hospitals about 1,000 cubic feet as a rule, and in infectious fever hospitals from 1,500 to 3,500 cubic feet; in these latter institutions the floor space allowed per bed is from 150 to 300 square feet. From the report of the royal commission on the housing of the working classes it would appear that even the low allowance of the common lodging houses is very often not attained in the crowded rooms of tenement houses, and an enormous number of cellars are still inhabited in our large towns, although they presumably come up to the requirements of the Public Health Acts as regards their ventilation.

Gas, candles, and lamps use up oxygen and produce carbonic acid and water. A cubic foot of coal gas produces, when burnt, 2 cubic feet of carbonic acid, and since a common burner consumes 3 cubic feet of gas in an hour, it produces 6 cubic feet of carbonic acid in the same period. Therefore, as much air should be supplied to dilute the products of its combustion as would be necessary for three or four men. It is far better, however, to use such gas-lamps as are shut off from the air of the room. These receive the air necessary for combustion from without, and the products of combustion are carried off by a special channel to the outer air. The electric light uses none of the oxygen of the air and gives off no carbonic acid nor water, and is for these reasons far preferable to naked flames for lighting purposes.

Ventilation is said to be carried on by natural or by artificial means. In the former are included (1) diffusion of gases; (2) action of the wind by perflation and aspiration; (3) movements caused by differences in weight of masses of air at different temperatures. By the latter, although the same principles are involved, is meant exhaustion of air by heat or by steam from apartments, or propulsion of air into such spaces by mechanical means, as fans. Diffusion causes a rapid mixing of different gases placed in contiguity; thus the gaseous impurities of respired air mix with the fresh air in a room until homogeneity is established.

Diffusion, however, does not affect the suspended matters, which tend to fall in a still atmosphere. Consequently, organic matters, which exist principally as minute solids in a state of suspension in the air, are not affected or removed by diffusion. The wind when in motion causes a partial vacuum in the interior of tubes, such as chimneys and ventilating shafts, placed at right angles to its course. The air in these tubes being thus partially aspirated or sucked out by the action of the wind, to restore the temporary vacuum so made, air from below rushes up to take its place, a continual current in a perpendicular direction being thus set up. Perflation by winds is the setting in motion of masses of air by the impact of other masses. This action is illustrated when the windows on opposite sides of the room are fully open. The room is rapidly and continually flushed with air, an enormous effect being produced, for it has been estimated that the air of such a room may be renewed many hundred times an hour, even when the movement of air outside is only 2 miles an hour, or 1½ feet per second, equivalent to a very gentle and almost imperceptible breeze. Such a method is of unquestionable utility for rapidly changing the air of an unoccupied room, and may be generally put in operation in summer in inhabited rooms when the temperatures outside and inside the house approximate. In any system of ventilation that depends entirely on the wind, there is always the difficulty of regulating the velocity of the current according to the amount of movement of the air, and during complete calms the action is *nil*. For ventilating the holds and interiors of ships at sea, the wind may be most advantageously utilized. A cowl placed so as to face to the wind conducts the air below, while another reversed so as to back to the wind allows the used air to escape.

The movement due to masses of air at different temperatures is the natural force chiefly relied on for ventilating the interior of houses. The air of inhabited rooms in this climate, except in warm summer weather, is at a higher temperature than the outer air; hot air is lighter than cold air, and will rise for cold air to take its place—in fact, heated air is displaced upward by colder and denser air. In a room as usually constructed with sash windows, with a fireplace and chimney, but without any special means of ventilation, when a fire is burning in the grate the heated air of the room in part ascends the chimney-flue, and in part rises to the ceiling. Cold air from outside will then enter, if the windows be closed, under the door, under the skirting boards, between the sashes of the window, and through any other chinks or apertures due to loose fittings. The bricks and plaster of the walls are also porous to a slight extent, and, if not covered with paint or wall paper, will admit air to a limited extent. Thus a large volume of air may be entering a room in cold weather when the fire is burning, although there be no visible inlets, and the amount of air thus supplied may be sufficient for the needs of two or three persons if it were properly distributed. But such is not the case. The cold air, which enters chiefly near the floor, takes as straight a course as possible to the fireplace, producing a disagreeable draught to the feet of the occupants, while the heated and vitiated air near the ceiling is left undisturbed. It has been found practically that to prevent draughts, and to insure a thorough distribution, fresh air should be admitted into a room above the heads of the occupants, an upward direction being given to it, so that it may impinge on the ceiling, mix with and be warmed by the heated air in this situation, fall gently into all parts of the room, and be gradually removed by means of the chimney-flue or any other outlet. The inlet openings for fresh air now most in use are intended to serve this purpose. For sash windows, Hinckes Bird's method, now so well known, of placing a solid block of wood under the lower sash of the window, so as to raise the top of the lower sash above the bottom of the upper, admits the air in an upward direction to the ceiling above the heads of the occupants.

Holes bored in a perpendicular direction in the bottom of the upper sash, louvered panes to replace one of the squares of glass, an arrangement for allowing one of the squares of glass to fall inward upon its lower border and providing it with side cheeks, or a double pane of glass in one square open at the bottom outside and at the top inside—all effect the same purpose, and are simple and inexpensive contrivances. Wall inlet ventilators, as the Sherringham valve and Tobin's tubes, are constructed on the same principles, fresh air, which in towns may be filtered through muslin or cotton wool, or made to impinge upon a tray containing water so as to deposit its sooty particles, being admitted at a height of about 6 feet from the floor and directed upward toward the ceiling. The usual outlet for vitiated air is the chimney flue, and this for an ordinary medium-sized sitting-room, with a fire burning, is sufficient for three or four people, provided no gas is alight, or the gas lamp has its own special ventilating arrangements. With an ordinary fire, from 10,000 to 15,000 cubic feet of air are drawn up the chimney in an hour. Valves placed so as to open into the flue near the ceiling are sometimes used as outlets for foul air; such are Neil Arnott's and Boyle's valves, which permit air to pass into the flue, but prevent its return. The only objections to their use are that they occasionally permit the reflux of smoke into the room, and their movements backward and forward cause a slight clicking noise. In all new buildings where efficient ventilation is desired, it would be preferable to construct a shaft at one side of or surrounding the chimney flue, with an inlet near the ceiling of the room and the outlet at the level of the chimney top, so that the air escaping from the room would have its temperature kept up by contact with the chimney, thus aiding the updraught, while the risk of reflux of smoke would be avoided. In all new domestic buildings, a very great improvement might be effected by providing for the warming of the air before its entry into the apartments. The window and wall inlet ventilators just described are occasionally productive of draughts in cold weather, so that it is more usual to find them closed or stopped up than in action, or else admitting a very insufficient supply of air; but if the air be warmed, before admittance, to an agreeable temperature, a very large amount may be allowed to enter without the fact being known to the occupants. The ventilating stove invented by Captain Galton, the Manchester school grate, and other forms effect this purpose in the following manner: Behind the grate, which is lined with fire clay, is a chamber into which fresh air is admitted by a pipe from the outside. The air, here warmed, is admitted into the room by a pipe opening at about the level of the chimney breast, and guarded by a grating which can be opened or closed as found convenient. In the Manchester school grate, the warmed air is admitted by vertical pipes, like Tobin's tubes, opening on a level with the chimney piece. The danger in these grates is that cracks may be formed by the heat of the fire in the joints or in the cast-iron plates which surround the air chamber, and thus direct communication be established between the grate and air chamber, with the result of deleterious products of combustion being admitted into the air of the room. When the stove is lined with fire clay, there is no danger of the air in the chamber being overheated, producing charring of the organic matter in the air and an offensive smell, which is so often noticed around stoves where this precaution has not been taken. In Mr. Saxon Snell's ventilating thermhydric stove, the fresh air is warmed by passing over hot-water pipes in the stove before entrance into the room, the hot water being derived from a small boiler at the back of the grate. The temperature of the water is not high enough to overheat the air.

Gas is being gradually introduced for heating purposes, and with a reduction in its price we may look forward to its more extended use. There are several ventilating gas stoves by which air is admitted into a room warmed after passing through the stove. It is important to regulate the heat carefully, so as not to overheat the stove and the air which is passing through. In churches and other public buildings air is usually warmed before entry by passing over hot-water pipes which circulate around the building under the floor. In all large buildings the combustion of gas may be made a very effective means of getting rid of foul air. It has been found by experiment that the combustion of one cubic foot of coal gas causes the discharge of 1,000 cubic feet of air. In theaters, where gas, although being gradually replaced by the electric light, is still much used, the extraction of foul air from the roof of the building by the sunlight burners presents no difficulty. The difficulty experienced is the introduction of fresh air from below without causing draughts. In private houses the use of an extraction shaft over the gas chandelier, or a Benham's ventilating globe light, or a Mackinnel's ventilator, greatly aids the extraction of foul air from the ceiling, while the two latter are also useful in providing inlets for fresh air, which enters slightly warmed near the ceiling, and is then directed horizontally by flanges so as to be distributed over the room. Outlets in the ceiling of a room may become inlets when a strong fire is burning, as the draught up the chimney will overbalance the extractive power of the gas and cause all other openings into the room to be inlets. We may here mention an ingenious method for warming the air admitted by Tobin's tubes into a room; a row of small Bunsen burners encircles the tube at its foot, and the products of combustion are conveyed away by a tube which surrounds the Tobin and opens into the outer air.

In large public buildings, where expense is no object, a combined method of ventilation by propulsion and extraction presents many advantages. The amount of air admitted can be easily regulated, warmed, cooled, or moistened, and freed from impurities by filtration, and enormous volumes are capable of being so supplied by propulsion and removed by the extractive powers of a furnace. In the Houses of Parliament, where this system is in operation, air is propelled by rotatory fans along conduits to the basement, where it is warmed in winter by passing over steam pipes, and then passes upward through shafts into the space beneath the grated floor of the House. The heat can be regulated by covering the steam pipes with woolen cloths, and in summer the entering air can be sprayed with water or cooled by passing over ice in the conduits. The vitiated air in the House passes through a perforated glass ceiling in the roof, and is then conducted by a shaft to the basement of the clock tower, where it passes into the flue of a large furnace.

The introduction of electricity for lighting and of gas for heating purposes will, in the case of both public and private buildings, considerably modify the methods of ventilation now most generally used.—*Nature.*

THE MANUFACTURE OF TOILET SOAPS.

By C. R. ALDER WRIGHT, D.Sc., F.R.S., F.C.S.

LECTURE III.

IV.—MACHINERY AND APPLIANCES EMPLOYED IN THE MANUFACTURE OF BARS AND TABLETS.

(*a*) *Manufacture of Milled Soaps.*—It has long been known by perfumers and others working on a small scale that by well pounding in a mortar soaps made by the cold process, a thorough intermixture is effected, and in some cases a peculiar texture, or pearly scaly appearance, becomes developed. Of late years, these operations, formerly carried out laboriously by hand labor, have been effected by machinery; and the result of successive improvements in this direction has been finally to develop a system of manufacture possessing a number of advantages, one of the most salient of which is that, being carried out without heating the soap to any marked extent, the most delicate flower essences, made by *enfleurage*, can be incorporated with soap in this way without deterioration of perfume, such as would inevitably result were these scents employed in connection with molten soap. Another advantage is that the mechanical crushing and intermixing effected by a proper "mill" causes soap that has been artificially dried to some extent since manufacture to acquire a certain degree of plasticity, so as to enable it to be moulded into shape, somewhat as stale hardened glaziers' putty can be made plastic again by "working" it for some time; so that, in the end, the result is the production of tablets containing smaller amounts of moisture than those formed by remelting processes, and consequently not requiring any long exposure to warm air to dry and harden them before boxing for sale.

The manufacture of "milled" soaps is usually carried out by chipping up into shavings the bars of "stock" soaps used as basis, and subjecting the chippings to the drying action of a current of warm air for some hours, a series of latticed trays (or with perforated bottoms) being employed to hold the shavings, arranged vertically one above the other in a drying chamber, and sliding in grooves in the walls, so as to be readily inserted or withdrawn at pleasure. At the base of the chamber hot water or steam pipes run, so as to create an upward current of warmed air passing through the masses of shavings piled up on the trays, fresh air being admitted at the bottom. Sometimes the chamber is fitted, not with steam or water pipes, but with a subsidiary heating vessel consisting of a convoluted steam pipe arranged inside a wider tube through which a current of air is made to pass, propelled by a blowing engine, a fan, or falling water, or aspirated through by connecting the upper part of the drying chamber with a chimney or steam draught.

The slicing up of the soap is usually effected by a machine, consisting of one or more blades, set like the cutting iron of a plane radially along a disk (precisely as in certain forms of household vegetable slicers). Sometimes all the soap is dried down to the required point; sometimes part is pretty thoroughly dried, and the rest used undried. The slicers are placed in a hopper, which gradually delivers them between two horizontal rollers nearly in contact (preferably of granite), arranged somewhat after the fashion of a large coffee mill; the gearing, however, is so arranged that one of these rollers (No. 2) rotates faster than the other (No. 1), so that the soap slices are not merely crushed in passing between the rollers, but are also subjected to a rubbing action. In consequence, the partially crushed material adheres by preference to the roller moving with greater speed (No. 2), and is carried along with that roller for a half revolution or thereabouts, when it finds itself between roller No. 2 and another similar one (No. 3) moving still faster. In consequence, another crushing and rubbing action is set up (the distance between the rollers being suitably adjusted), and the material becomes transferred to No. 3 roller. Sometimes a fourth roller, moving still faster, is employed, and even a fifth on the same principle. Whatever the number of rollers, the film of thick, doughy

soap paste adhering to the last roller is scraped off by two sets of doctors with alternately placed scrapers, so as to deliver the scrapings into a box in the form of pasty ribbons some half inch wide. These ribbons are then transferred back to the original hopper, and the intermixture and crushing repeated, coloring matter, scents, and other ingredients being added and intermixed *ad libitum* during the milling. Usually the materials pass three or four times successively, or even more often, through the mill before they are ground to a perfectly uniform paste. A certain amount of warmth is communicated to the mass by the friction and crushing, which heat must not be allowed to rise to too high an extent.

The ribbons finally obtained are next transferred to a machine by means of which they are compressed and shaped into bars, which operation is known as "plotting" (*pelotage*). Two principal classes of machines are used for this purpose; one essentially consists of an engine cylinder filled with the ribbons, which are compressed by means of a hydraulic ram,* and finally "squirted" out through a nozzle of such dimensions and shape as may be requisite to form a bar of the desired cross-section—much as lead and "compo" tubes for gas and water supply are manufactured, except that no cooling of the emerging mass is required. The other kind of machine is a modification of the well-known "pug-mill" used in the pottery manufacture, consisting of a powerful horizontal conical screw fitting pretty closely into a conical barrel, with a hopper at the top of the wider end. As the screw revolves, the ribbons fall down from the hopper, and are caught in the thread of the screw, issuing under greatly increased pressure, owing to the conicality. At the narrow end of the conical barrel the mass passes through a plate perforated with a large number of holes, so that it emerges therefrom as a number of parallel rods; the *vis a tergo* causes these to weld thoroughly together, and to pass through a tapering mouthpiece furnished at the exit end with the die, or stout metal plate perforated with an orifice of the dimensions of the cross-section of the bar ultimately required (*i. e.*, round, oval, square, rectangular, or otherwise as desired). Finally, the bars are cut up transversely into blocks, which are stamped into tablets, and boxed for sale after a certain amount of standing, with exposure to air, to harden, and such dressing and polishing, etc., as may be required to give a nice "finish."

When required to produce a soap free from uncombined fixed alkali from stock soaps containing "free alkali," this may be effected in the mill, in accordance with the patented process referred to in a former lecture, by adding to the shavings, before their first passage through, an amount of an ammoniacal salt (such as the chloride or sulphate) equivalent to the average free alkali in the stock, preferably dissolved in as little warm water as possible. During the successive grindings, the ammonia and carbonate of ammonia formed during the neutralization of the free alkali become practically all removed by evaporation, which readily takes place from the thin ribbons scraped off by the doctors.

(*b*) *Machinery and Appliances used in the Preparation of Tablets.*—The bars produced by the plotting machines above described simply want cutting into suitable lengths, and allowing to stand a while, to be ready for the stamping operation which converts the pieces into tablets. For this purpose, machines are employed in which the block of soap (previously lubricated slightly with oil, glycerin, odorless petroleum, gum water, such as that made by adding water to "slippery elm" or other analogous substances) is compressed between a pair of dies, fitting within a ring or box, which determines the size of the tablet. A large variety of stamping machines for this purpose exist; in most, the impression is given by impact (as in stamping medals and coins), the dies being actuated by a lever or combination of levers, a cam, a powerful screw, or other suitable mechanical arrangement, such that a considerable pressure is given for the instant, and intensified by the momentum of heavy moving parts. In some machines, the upper die is driven after the fashion of a pile driver; in others, a powerful pressure is developed by hydraulic agency. A succession of blows is sometimes desirable; sometimes the tablets are shaped by means of blank dies, and then dried a while, and subsequently stamped again with the final dies, cut so as to give the proper impression. For light work, a press worked by the foot or hand suffices; for other kinds, stamps driven by steam power are required.

In the case of remelted soaps, and cold process or other varieties necessarily cast into blocks, the preparation of bars from the cooled blocks requires to be performed previously to cutting and stamping into tablets. The oldest and simplest method of procedure consists in drawing a thin wire, provided with handles at the ends, through the block horizontally, the operation being usually carried out by two men together, the exact line of cutting being previously marked out on the block. The slabs thus prepared are then cut up into bars, either in the same way or by a hand machine carrying a wire, which slices off at each stroke a portion of the slab, forming a bar, the width of which is regulated by a gauge. A variety of slabbing and barring machines are in use for carrying out these operations more rapidly and effectively when large quantities have to be dealt with, as in the manufacture of household soaps; for the most part these consist of a traveling platform, on which the mass of soap rests, and by means of which the soap is propelled against one or more strained wires, so that, as the soap travels, the wires cut it into slabs or slices. In some machines, two sets of wires are used—one a series of parallel vertical wires, the other a similar series arranged horizontally, so that one motion of the traveling platform effects the division of a block into slabs, and also of each of these slabs into bars. These methods of cutting up ultimately result in the production of rectangular parallelopipeds of soap. To convert these into tablets, they are exposed to slightly warmed air for a short time, so as to produce a surface film of slightly dried soap, and thus avoid sticking to the dies when they are stamped. Tablets thus prepared are usually made from parallelopipeds smaller than the dies, so that the plastic mass is squeezed out and enlarged superficially (and correspondingly diminished in thickness) during stamping. A more or less strongly defined nearly square or oblong mark is apt to be thus produced, indicating the hardening edges of the small block, and to some extent disfiguring the tablet. To diminish and avoid this tendency, the parallelopipeds are often "dressed," or "shaped," by hand or otherwise, before stamping, so as to attain approximately the shape of the finished tablet, a kind of knife, or a "soap-plane," or a mechanical cutter, being employed for the purpose. The scraps thus produced, together with the ends of the bars and the outsides of the blocks cut off to trim them before slabbing, etc., often amount to a very considerable fraction of the block, especially when of comparatively small dimensions (*e. g.*, weighing only one, two, or three cwt.); thus, from 25 to 33 per cent. of the block, and sometimes more (if the block has shrunk irregularly in cooling, requiring a thicker outside slice to be removed in dressing), is usually reduced to scrap, which has to be utilized by remelting, either by itself or along with the next batch of the same kind. This, of course, entails loss of labor and time, while perfume is lost by volatilization, and frequently the soap is somewhat deteriorated, especially if the scrap has to lie by and harden for some time before being used up for another batch of the same color and kind.

* In the older forms of "cannon" machine, a powerful screw, worked by steam, is used to actuate the piston which compresses the ribbons into a solid mass, and ejects them as a compact bar.

In order to avoid or diminish this waste, it has been frequently attempted to form the cast blocks into bars by compression, without cutting; but hitherto the processes suggested for this purpose do not seem to have come largely into use. One of the earliest methods proposed consisted in placing the block in the barrel of a kind of gigantic syringe, furnished with a piston, by means of which the mass of scrap is gradually forced out through a plate perforated with holes, each of which acts like the die-plate of the barring machines already described in connection with milled soaps, so that the soap emerges as a series of bars. Recently, further developments of this idea have been patented, a hydraulic ram being used to give the requisite pressure, and a special arrangement for the introduction of fresh soap after completion of the first stroke. With soaps sufficiently moist and plastic to "give" under pressure and weld together completely, machines of this sort can be employed to produce fairly compact bars; but many compositions used for toilet soaps crack and flake when thus treated, to such an extent that the bars ultimately formed cannot be worked up satisfactorily into tablets, inasmuch as, although the tablets formed look all right when finished, yet they are liable to break into pieces when used for washing hands, etc.

A recent patent of my own avoids this inconvenience, and also does away with the necessity of using moulds or frames for casting the soap into blocks, the molten soap being "squirted" directly into bars by means of a syringe-like arrangement propelling the soap through cooling tubes surrounded by water at a proper temperature, and finally through one or more moderately long final cooling and shaping tubes, furnished with nozzles at the far ends determining the dimensions of the cross sections of the bars that emerge. When the temperatures of the cooling tubes, etc., are properly adjusted relatively to the nature of the soap operated upon and its speed of passage, perfectly formed, sound bars are obtained of any required shape as regards cross section (just as with the barring machines used for milled soaps). Practically, no loss by formation of cuttings and scrap is occasioned, while a considerable saving in time, labor, working space, and plant is effected.

Instead of tablets, many persons prefer to use globular masses of soap, or "wash balls." These are sometimes moulded by compressing a mass of plastic soap (previously roughly shaped by rolling between the hands, on a table, or between dished plates provided with handles) between hemispherical dies; but the better kinds are cut from a solid block and turned in a little machine (something like an apple parer) provided with a curved planing iron which gradually cuts the mass to shape. Sometimes several successive parings, with alternate rests for drying, are requisite.

No matter what the shape of the stamped tablet may be, in many cases it is desirable to give an extra "finish" and polish to the surface by hand treatment, such as rubbing with a cloth or piece of felt moistened with spirit. In many cases exposure to wet steam for a few seconds develops on the surface a film or glaze of remelted soap, possessing an admirable gloss without any further manipulation being requisite.

I cannot conclude the discussion of this branch of the subject without expressing my thanks to Messrs. J. C. and J. Field, for supplying a large proportion of the numerous exhibits shown, illustrating the raw materials used in soap making, and the manufacture therefrom of the principal varieties of household and manufacturers' soaps; to Mr. R. Houchin for the loan of a number of the various machines constructed by him, and used to illustrate the various processes of cutting, shaping, and stamping soap tablets; also to Mr. F. A. Field for the preparation of a number of the diagrams of various kinds of plant and appliances too cumbrous to be actually brought into a lecture room.

VALUATION OF TOILET SOAPS BY CHEMICAL ANALYSIS. SUBSTANCES FOUND IN TOILET SOAPS AS SOLD.

A certain portion of the cost of manufacture of a first-class toilet soap depends necessarily upon conditions as to which chemical analysis leads to but little distinct information, these circumstances more especially relating to the costliness of the perfumes used in scenting it and the amount of labor bestowed in moulding and finishing it. But these circumstances have no necessary connection with the value of the soap *as such*; as regards the main characteristics of a thoroughly good soap, not only can these be satisfactorily ascertained during the course of analysis, but, further, in no other way can the absence of objectionable constituents be completely proved.

The list of substances incorporated with various kinds of toilet soaps (partly as adulterants or "filling" intentionally added, partly as constituents intended to improve the article or to give it special qualities), together with the normal materials contained in such products, is a lengthy one, comprising, among other things, the following:

Alkalies: Potash, soda, and sometimes, but only rarely, ammonia, present in the form of actual soap, *i. e.*, alkalies combined with fatty or resinous acids.

"Free" alkalies: consisting of these substances present in a form capable of neutralizing acids other than that of genuine soap, *i. e.*, alkaline matter not combined with fatty or resinous acids.

Neutral salts, more especially sulphates and chlorides (also including such semi-neutral salts as borax).

Fatty and resinous acids combined with alkalies forming actual soap.

Ditto present in the free state or as more or less imperfectly saponified glycerides.

Glycerin.

Glycerin "substitutes," *i. e.*, adulterants, more especially sugar.

Pigments and coloring matters.

Water.

Alcohol, volatile scents, essential oils, etc.

Organic materials added, either to increase the bulk or to communicate special qualities, such as powdered odorous roots and woods, farina, gelatin, dextrin, and gums of various kinds; oatmeal, bran, sawdust, and other vegetable matters; also beeswax, spermaceti, vaseline, ozokerite, petroleum, crude coal tar, and more or less purified coal tar distillates, including carbolic acid and creosote oils, and Stockholm and other vegetable tars.

Inorganic materials added for similar reasons, such as fine sand, infusorial earth, varieties of china clay and pipe clay, French chalk and fuller's earth, precipitated chalk, sulphur, and such like bodies.

For the complete analysis of soaps, including the quantitative determination of these and other constituents when present, various more or less successful methods have been propounded by different analysts, into the relative merits of which time will not permit me to enter; but I may point out that a considerable experience has led me to the conclusion that a very fair estimate of the general character and value of a toilet soap may be formed without quantitatively determining every possible constituent present, the data more especially requisite for deducing such conclusions being the following:

Total alkali present, including—

Alkali combined as actual soap.

"Free" alkali, *i. e.*, alkali not so combined, but capable of neutralizing acid.

Fatty matters present, including—

Fatty (and resinous) acids combined as actual soap.

Ditto, not so combined (free acids and unsaponified fats, etc.).

Glycerin (when present).

Together with qualitative tests as to the odor, melting point, and general properties of the fatty acids present; and similar tests (so performed as to give a rough idea of relative quantity) for poisonous metallic pigments (more especially compounds of mercury, as vermilion; copper and arsenic, as Scheele's green and other analogous pigments; and lead, as red lead and chrome lead), and for other matters insoluble in water (farina, French chalk, etc.), and for soluble matters, such as sugar and sodium chloride, etc.

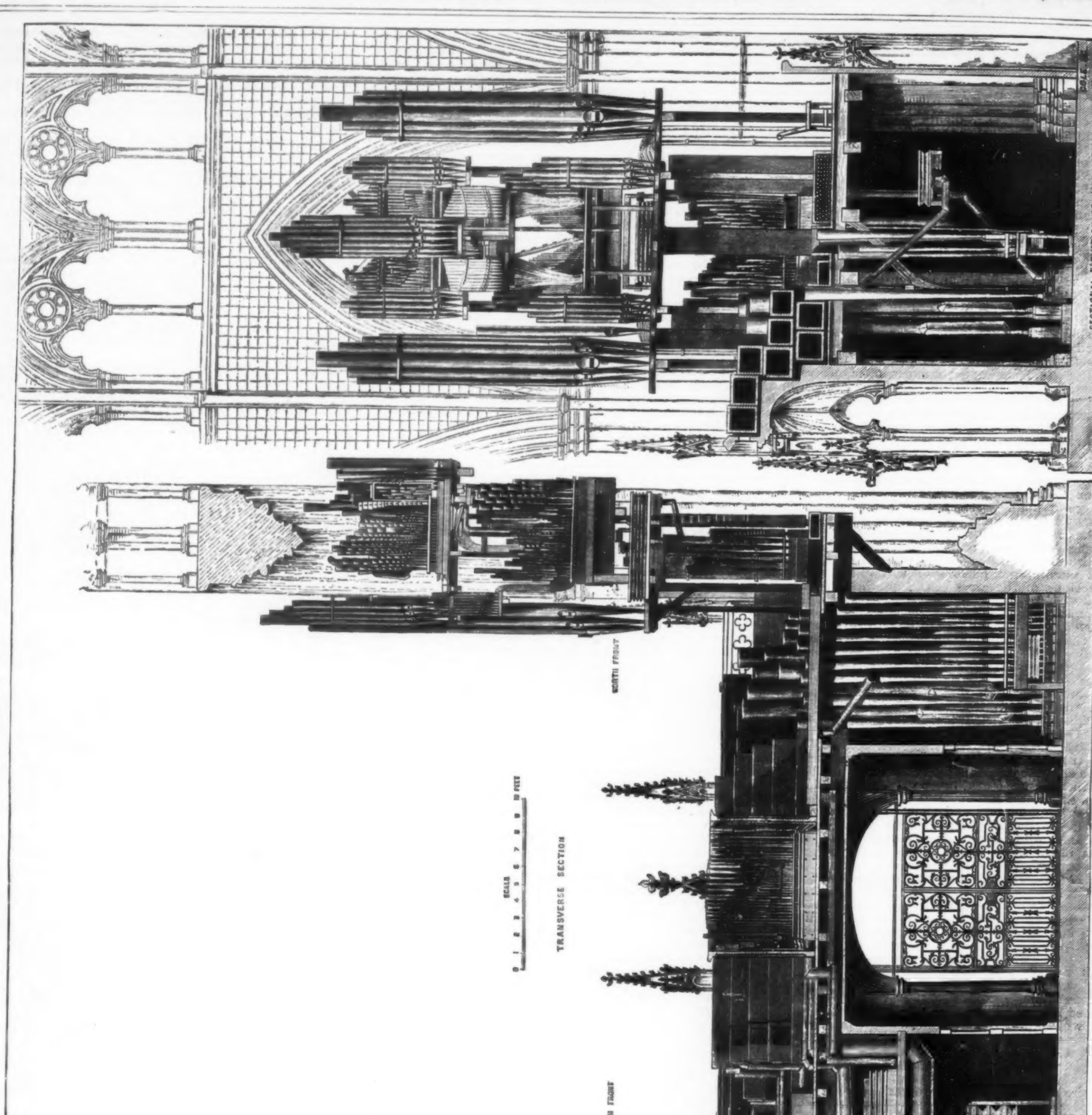
DETERMINATION OF TOTAL ALKALI, AND OF FATTY ACIDS FORMED ON DECOMPOSING THE SOAP.

For the estimation of the total alkali present, the ordinary volumetric processes are conveniently available, the most simple method being to dissolve a known weight of soap in hot distilled water, and gradually add to the solution standard acid, shaking or stirring vigorously after each addition, until all the soap is decomposed, and the fatty acids that swim up to the top in a fused condition retain no more alkali in the form of traces of intermixed or dissolved soap. I prefer cochineal as the indicator when working in this way, as artificial light does not notably interfere with the color change when the acid is added until no further alteration in tint takes place (the acid being standardized with pure alkali in just the same way). A preferable modification is to add a measured quantity of acid—more than sufficient to neutralize all the alkali present—and shake or stir thoroughly; when the fatty acids have wholly separated, the excess of acid in the aqueous liquor is titrated.* The fatty matters thus separated may be collected and weighed with or without the addition of pure wax, to give the cake of cooled fatty acids sufficient consistence to bear handling. Greater accuracy is usually supposed to be attained by dissolving the fatty acids in ether or low-boiling petroleum spirit, separating by a stop-cock funnel, and evaporating off the solvent. My own experience, however, rather tends to the conclusion that this method is more troublesome, and about as likely to introduce errors as to eliminate them, on account of the difficulty in getting rid of traces of water when ether is used, and of higher-boiling petroleum constituents when petroleum ether is employed, these sources of error necessarily tending toward overestimation.

In order to determine the amount of uncombined fatty acids or of unsaponified fat present, the soap may either be dried and powdered, and treated with ether or petroleum spirit, to dissolve out matters soluble therein, or may be dissolved in a minimum of water, and agitated with these solvents. The weight of matter thus extracted, when subtracted from the total fatty acids obtained as above, gives the quantity of fatty (and resinous) acids present combined as soap; the extracted matters, however, do not necessarily consist of fatty acids or unsaponfied fat, inasmuch as many fats and oils contain small quantities of constituents which can be thus separated from the soap made from them, but which are not themselves glycerides or fatty acids. Moreover, if beeswax, vaseline, ozokerite, or allied substances are contained in the soap (being added intentionally to give certain specific qualities), they will be thus dissolved out and separated; so that a further analytical examination of the extracted matters is necessary when they are present to any marked extent.

Fixed Alkali.—Of all the *quantitative* analytical data obtainable on the examination of a toilet soap, by far the most important one is the determination of the "free alkali;" while the discrimination of the nature and character of the fatty matters employed in making the soap is of almost equal importance. Unfortunately, several methods are in use among analysts for the determination of "free alkali," which are not of equal trustworthiness, as they often differ considerably in

* When both soda and potash are present simultaneously, a quantitative determination of the latter must be made, from which, and the volumetric process, the former may be deduced.



THE NEW ORGAN, WESTMINSTER ABBEY, LONDON.

their results. With a view of determining once for all which methods are to be preferred, and which are only misleading, I have (in conjunction with Mr. C. Thompson) made a searching comparative examination of these methods. The present occasion is not suitable for the complete discussion of all the results obtained, but the following brief synopsis of these results may be of interest, the detailed description being reserved for communication to another society.

The three principal methods in use may be conveniently distinguished as the *alcohol test*, the *fatty acid titration process*, and the *salting-out test*. The first of these consists in treating a known weight of soap (preferably dried previously) with strong alcohol, filtering hot, and titrating any caustic alkali in the filtrate, using phenol phthalein as indicator, while the residue left undissolved on the filter (consisting of carbonates, etc.) is dissolved in water, and also titrated, the sum of the alkalinities thus formed being reckoned as "free alkali." Besides being by far the most accurate process of the three, according to our experience, this method has the advantage of discriminating between that part of the free alkali which is present as *caustic* alkali, or hydroxide, and that part present as other forms of alkaline matter, ordinarily far less violent in their corrosive action on the skin. For the purpose of toilet-soap examination, however, this distinction is not of paramount importance, inasmuch as only the very worst kinds of carelessly made soaps contain free alkali in the state of hydroxide to any notable extent, although many soaps, even those prepared by makers of reputation, contain considerable amounts of carbonated alkali; in many cases this form of free alkali is intentionally introduced, either as carbonate of soda, to give hardening qualities, *i. e.*, to "close up" the soap, or as pearlash (carbonate of potash), to improve the texture—a most objectionable practice from the point of view of a consumer possessing a tender, sensitive skin.

(*To be continued.*)

THE NEW ORGAN IN WESTMINSTER ABBEY.

THE modern organ possesses a structure so ingenious that it presents a great deal which cannot and does not fail to interest engineers. Its mechanical details, indeed, are marked throughout by a remarkable perception of the proper means required to attain a given end; and the splendid instrument which we illustrate is replete with mechanical refinements, which render it in every respect worthy of study.

The music of an organ is produced, as is well known, by blowing air into pipes. These pipes may be divided into two distinct classes, technically known as flue pipes and reed pipes. The first are neither more nor less than whistles; they vary in size from about ¾ in. long and ⅜ in. in diameter to over 32 ft. long and 2 ft. in diameter, or even in some cases to 3 ft. square. In all cases they have a slot, in a flat plate or languid, as it is sometimes called, through which the air rushes and is split into two columns by a sharp edge or tongue. The column which ascends inside the pipe is thrown into vibration in a way not clearly understood, and produces a musical note depending for its place in the gamut on the length of the column of air vibrating inside the pipe. By stopping up the top of the pipe, an effect is produced equivalent to doubling the length of the pipe. Thus, a stopped 16 ft. pipe is equivalent to an open 32 ft. pipe, but there is a sacrifice of tone quality entailed. As to the *character* of the note, that depends on the material of the pipe and its shape, especially at the mouth.

Pipes of the second class are called reeds, because, instead of resembling whistles, they derive their sound from vibratory tongues or reeds, and they also are of all sizes, from that of a child's penny trumpet up to 32 ft. long. Here, again, while the position of the note in the gamut is determined by the length of the pipe, the quality or nature of the note is settled by the reed and the shape of the pipe. Various pressures of wind are used for different sets of pipes or "stops." The pressure varies between about 4 in. and 14 in. of water. In some foreign organs very high pressures—as much as two or three pounds on the square inch—have been tried, to produce special effects; but the high-pressure system has not been successful. A common defect in organs is "overblowing"—that is to say, working with too high a pressure, which always tends to produce harshness of voice.

Each pipe in an organ can produce but one note, and consequently for every note there must be a separate pipe; but besides this each key may control several stops, in which case there is an equal number of pipes. Thus, if we take an octave controlling five stops, we have thirteen tones and semi-tones, and 5×13=65 separate pipes. That is to say, we have five D's, five C's, and so on, and the D key is able to sound D on, let us say, a Hohl flute, a dulciana, keraulophone, a cor Anglaise, and a Suabe flute. By the use of sliders—thin plates of wood with holes in them—pushed in and out by the draw stops at the side of the organist, any one or all of these pipes may be shut off. If all the five stops we have named are pulled out at once, then, when the key D is put down by the organist, all the D pipes of the stops we have named will speak. If they are all pushed in but one, say the Suabe flute, then that only will be heard. The organist has therefore, in a sense, a band under his control, and much of his talent is shown by the way in which he combines his stops to produce the best orchestral effect.

Furthermore, it must not be forgotten that every organ of any importance is composed of several distinct instruments, each controlled by its own separate keyboard. Thus, in the Westminster organ there are four keyboards and a set of pedals, or five organs in all, but, by a very ingenious arrangement known as a coupler, the keyboard of any one organ can be made to control the keys of any or all the others. A full list of the couplers, no less than twelve in number, of the Westminster organ will be found further on.

In order to admit the air to the pipes, valves, technically known as pallets, are employed; these are really hinged valves faced with leather. Each key controls one valve, no matter how many pipes—stops—there are to that key. The pulling down of the hinged valve admits air under pressure to a long, narrow box on which all the pipes for the given note of the various stops are planted. When the valve is opened, all the pipes on that box would speak if it were not for the sliders, which, when in, stop the mouths of all the pipes. Only that pipe can speak whose sliders happen to be drawn out; for although pressing down the key has admitted air to the box, the air cannot get out of the box to the pipe unless the sliders are in the proper position—that is to say, unless the stop is pulled out. It will be seen that the sounding pipe need not be planted on the box. It will suffice if a small tube is led from the box to it; and in nearly all large organs this is done, especially in the case of the large pipes, which could not be planted on a "sound-board," as it is called, of reasonable dimensions. As lightness of touch is essential to the production of good music, it is essential that the valves (pallets) should move with very little resistance. In the best modern organs what is known as a pneumatic arragement is employed. The principle involved will be readily understood. The pallets proper must be of considerable size, especially for the larger pipes, and their resistance would therefore be great even when balanced, because balancing cannot be carried too far, or the pallets would not shut with sufficient promptitude. To get over the difficulty and take the strain off the organist's fingers, the keys control small pallets carefully balanced, and these admit wind to valve boxes, which wind pulls down the pallet controlling the speaking pipes. The arrangement closely resembles that in use in some steam pumps, where a very small valve admits steam to work a large valve.

It will be understood that it is necessary to place the pipes of an organ in various positions, and a glance at the opposite cut will show that the pipes are scattered over a great area; some are on the ground floor or floor level of the Abbey; others stand high up near the roof; others, again, are behind the organist, who sits in the center of the screen facing the north. In old practice, there was only one way of connecting the keys with the pipes, namely, by light rods of wood and wire called trackers, which were always heavy to move and liable to get out of order. In the Westminster organ, air tubes are used instead of trackers, and the motion of the key under the organist's finger is responded to by the instantaneous opening of pallets all over the organ under the impulse of the air pressure transmitted through these tracker pipes, as we may call them. The sliders are worked in the same way. Nothing can be more elegant in its application or satisfactory in practice than this beautiful system of transmitting power to a distance.

The Westminster Abbey organ is one of the most representative among the great organs which have lately been built in this country. Few church organs are of larger size regarding the number and variety of stops, and none exhibit a more complete system of scientific action and appliances of the most recent class of invention. The organ which has now given place to the new instrument was built in 1730 by Schreider and Jordon, who were well-known and excellent builders of their time. The scope of English organ-building in the eighteenth century was, however, extremely limited, and in no way to be compared with the art as practiced on the Continent, especially in Germany, where fine, large organs were built before the time of Bach. The Abbey instrument consisted of three manuals, of which the great and choir extended to G G, and the "echo" or swell to fiddle G only; while no pedal organ whatever was thought necessary, although this department was duly recognized a century before among our German and other neighbors. Avery added some pedal pipes—probably an octave only—at about the end of last century, and a few other alterations seem to have been made at that time.

In 1828 Messrs. Elliott and Hill supplied a new swell organ to tenor C, and extended the pedal pipes to G G G, 24 ft. This was not the first occasion when this old firm had charge of the Abbey organ, having obtained the care of it at the beginning of the century, since which time it has received treatment from their hands only. In 1848 Messrs. Hill added an additional octavo to the swell, thus extending its compass to C C, with extra stops of various kinds. The great organ was increased in size and enlarged to the C C C compass, and the pedal keys made to act upon the great clavier, and the pedal pipes carried down to C C C C, 32 ft. This same firm in 1868 added a fourth manual, or solo organ, with a tuba, vox humana, and other solo stops, though great difficulty was experienced in finding room for these additions on the screen, already much encumbered by the 32 ft. pedal pipes, which were laid horizontally for want of space on the north and south side.

Although these last alterations greatly added to the efficiency of the organ, yet there were many defects in the instrument as judged from a modern standpoint, the chief being the absence of a separate pedal organ, the cramped-up arrangement of the sound boards, and the C C C compass of the manuals. Mr. Turle, the late organist, was so accustomed to his instrument that he thought little of these imperfections, and it was only on the appointment of Dr. Bridge that attention was turned to the necessity of a complete alteration in the Abbey organ. For some time, however, the scheme was abandoned, and it was not till 1883 that Messrs. W. Hill & Son's plans for the rebuilding were finally accepted by the Chapter. It was then resolved entirely to reconstruct the organ, retaining only such stops and certain sound boards of the old instrument as could be conveniently used again, and in doing this the most conservative spirit was manifested. The old great organ was originally on the north side of the screen, under the arch; the swell on the south, the choir and solo in the center of the screen, and the pedal lying horizontally. It was determined greatly to increase the height of both the north and south organs; the great, solo, and portion of the pedal to occupy the former position; the swell and other portion of the pedal the latter; while it was found best to place the choir organ in the center of the screen—toward the west—allowing the console to occupy a middle place, which will enable the player to see both the decani and cantoris sides of his choir in the stalls below. The space within the walls of the screen on the north side was also appropriated for the reception of the great thirty-two foot pedal reed, which requires considerable space. For some time the question of blowing and blowing power remained undecided, but eventually it was determined to construct a special vault in the cloister green, which could contain the blowing feeders, and also a gas engine to drive the same; and arrangements were made for taking the wind into the Abbey by means of underground pipes of large size passing from the vault to the reservoirs within the organ itself.—*The Engineer.*

ON THE TESTING OF EMERY AND CORUNDUM.

By NELSON H. DARTON.

THERE are but few materials that are in such general use as emery which vary as much in hardness and quality as this useful abrasive. The causes of this variability are comparatively well understood by the few who have thoroughly investigated the matter, and a general statement of these causes may be of value in the selection of emery and emery ores.

The nature of emery was thoroughly investigated by the late Dr. J. Lawrence Smith, and it was found that it is an impure form of the mineral corundum, the amount and nature of the impurities varying greatly, and by their interference with the cleavages of the corundum affecting the hardness by varying the structure, and, generally being very much softer, decreasing the hardness in proportion to their amounts. Chemical and mineralogical examinations were shown to afford considerable evidence upon the probable hardness and purity of the emery, but fail to point out the structure and arrangement of the impurities of which they show the existence. When supplemented by microscopic examination, very satisfactory results may be obtained, but these processes are only of value in the hands of an expert, and then taking much time for their execution.

With commercial corundum the case is very similar; and this material, now coming into very general use on account on its superior hardness to emery, varies much more than would be supposed.

There are two classes of corundum, and they grade into each other imperceptibly. The most common variety has the two cleavages very prominent, and the third frequently present; it breaks down into splintery fragments, and, although cutting rapidly, is not so powerful and lasting as the other variety, which is without prominent cleavages and is dense and granular. The two varieties often occur at the same locality, at Buck Creek, in North Carolina. The granular variety greatly preponderates, and is an extreme of its class; much of the corundum now in the market is very impure, containing other and softer minerals, and is often mixed with quartz.

Several mechanical methods have been proposed for testing the abrading power of emery, etc. Dr. J. L Smith's is the only one yielding reliable results. The writer has had a long and satisfactory experience in its use, and it has been found possible to improve it in many details, which has made it more readily manipulated, and useful to many who are not sufficiently skilled to observe all the refinements of manipulation necessary in the original process, and the neglect of which makes the results of but little value.

It is trusted that a detailed description of the process will be valuable to many who have occasion to use or handle emery, and either have not known or could not obtain satisfactory results with the method as originally proposed.

This process was to reduce the mineral to about No. 60, and grind it down dry on a glass plate by rubbing with an agate. By weighing the plate before and after the operation, the amount of glass ground away was found; and comparing this result with one similarly obtained from sapphire, which was used as a standard, the relative abrading power of the emery was found. By grinding the polish off the glass plate before the test, and then using the emery made in a paste with water, it was found by many careful experiments that the time and possibility for error were reduced greatly; and many minor details increase the practicability of the process.

When the emery is in the crude state, it is necessary to reduce it to a grain of suitable fineness for the test, and the selection of a sample for this purpose is a very important preliminary, which requires the exercise of much judgment, especially if the sample is to be a small one and of uncrushed ore. As large a quantity as possible should be taken, and reduced to fragments of about the size of a pea, in a crusher or by breaking in an iron mortar. It is then to be freed from smaller grains by passing over a No. 8 sieve, and a sample drawn from it by "quartering down;" the quantity need not exceed an ounce.

This sample is then to be reduced in a small steel diamond mortar, or, if this is not at hand, an ordinary iron mortar will answer. Very small portions should be taken each time, and broken by one or two hard, quick blows, and, when the grains become smaller, a slight rotatory motion should accompany the pressure; care should always be taken not to break the emery too fine by much hammering.

When each fragment of the sample has been broken, all should be passed over a No. 8 sieve, and the remaining fragments broken until of that size; the product should then be graded by passing over a No. 16, then Nos. 24, 40, and 60 sieves. All coarser than No. 16 is then broken until it passes through No. 16. The product is again graded and added to the results of the first separation, and this process is progressively continued until all passes through a No. 60 sieve; all finer than No. 70 is separated and discarded, as No. 60 has been found to be about the best size for the test, representing as it does the average grade of those generally prepared. No. 40 may be used, but is not so easy of manipulation as No. 60, and the ore may be reduced to size without the progressive separations advised above; but the results are more apt to vary when these details are not observed, as the emery wears itself down very irregularly when much is reduced at once, and a larger amount of iron is ground off the mortar, and decreases the cutting power of the abrasive. These particles of iron cannot be separated by the magnet, as much of the emery is also attractable.

It is quite obvious that emery prepared as above described must differ in shape of grain from that produced in the regular milling process, and consequently it can never be fair to compare the two except for general results; and the regularly manufactured product will generally be found to give much better results, as a greater part of the impurities of the ore are separated.

One should also bear in mind, in the comparison of two ores, that they may yield different comparative results in the milling than in the hand process; and

again, when subjected to different processes of manufacture, may be made to differ in quality. The writer has recently met with instances in which an emery ore slightly inferior to another, when reduced by hand, yielded in the hands of a miller a better product than the other, but by a different process of preparation, which eliminated much of the impurities and produced a more effectively shaped grain. From these instances we are cautioned to use the process below described only as a comparative one, and always under exactly the same conditions and with the same object in view. Its value, then, is chiefly in comparing the value of manufactured emeries, and for ore it can only be considered as partially satisfactory.

The glasses for the test may be of ordinary French plate about 3/16 inch thick and four inches square; they are prepared for the test by grinding off the polish with a paste of No. 80 emery and water, applied on a cloth, and will only occupy a few moments for each. When ground they are well washed, dried, a distinctive number marked upon them with a piece of emery, corundum, or a diamond, and carefully weighed. It is desirable, in making many tests, to have a fixed method for preparing the surface of these glasses, in order always to have them of the same texture; as both sides of the glasses may be used, it is well to prepare both at once, and number them differently.

The amount of the abrasive to be taken for the test varies with the sensitiveness of the balance to be used for weighing it out. With a good chemical balance weighing to milligrammes, two grammes (or 60 grains) is sufficient; but for a balance less sensitive, as a good prescription balance, twice or thrice this quantity should be taken. The more used, the longer is the process.

The "rubber" should be of agate cut or smoothed to a plane face, at least an inch and a half in diameter, and of convenient shape for handling. The bottom of an agate mortar is well suited for this purpose.

All being ready, the emery is weighed out on a watch glass and mixed into a soft but solid paste with a few drops of water. A mass about 1/8 inch cube is placed in the center of the glass plate and rubbed thoroughly over its surface with the agate. The motion should be rotatory, the pressure moderate and uniform, and the process continued until the paste becomes impalpable. This is then scraped aside, and other similar portions placed upon the plate in succession and ground down. When all is finished, the scrapings are mixed together, and again worked over the plate until no grinding action is perceptible. The plate is then cleaned, washed, dried, and weighed. The operation is repeated, and if the loss in the last grinding is over five per cent. of the first, the operation should be again repeated until a satisfactory result is obtained.

Although emeries can be compared directly with each other by the results of this process, it is desirable to have a standard of comparison, as 100, and to reduce the various results to this standard.

The standard to use would appropriately be the black diamond, as it is the hardest of all minerals.

Corundum is much more practicable, and as the process above detailed is equally applicable to it, a standard may be readily obtained.

The corundum selected should be of the dense granular variety. I have found that from Buck Creek, N. C., to be the best suited. It occurs in rough-looking grayish-white masses without apparent cleavage, and in the mortar or at the mill yields about the same product, a buhrry grain, which wears down very slowly and has great cutting power, although cutting rather slowly.

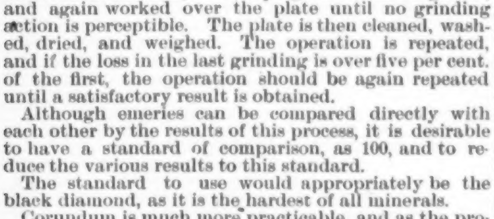
Corundum of this character is sometimes associated with the splintery variety, and a lump or two may generally be culled from any good sized lot of corundum. It should be reduced to No. 60 and freed from iron particles by the magnet. A good emery should stand about 55 in comparison with this corundum as 100.

RULE FOR FINDING DIRECTION OF CURRENT AND NORTH POLE OF MAGNETS.

By J. D. F. ANDREWS.

KNOWING the direction of current in the wire of an electro-magnet, then the thumb of the right hand will point to the N. pole when the palm of the hand is placed on the coil, with the fingers parallel to the wires, and pointing in the direction of the current.

Knowing the N. pole of a magnet, then the fingers



will point in the direction of the current when placed parallel with the wires, with the palm of the hand on the coil and the thumb pointing to the N. pole.

The N. pole of a magnetic needle will deflect toward the thumb of the right hand when the palm is placed on the wire, with the fingers parallel to it pointing with the direction of the current producing the deflection. Conversely, if a magnetic needle deflects toward the thumb of the right hand, with the palm on a wire over the needle and the fingers parallel with the wire, then the fingers will point with the direction of the current. The above rules are exceedingly handy in the construction of dynamos, and are easily remembered by workmen who have to connect up the coils, etc.—*The Electrician.*

ELECTRIC TRANSMISSION OF POWER BETWEEN PARIS AND CREIL.*

Now that the Creil experiments have closed the numerous and often intemperate discussions that have taken place concerning the question of the transmission of power by electricity, and have put an end to the period of tentatives, it will be not without interest to cast a glance backward, and briefly recall the results obtained during this first period, which, so to speak, is one through which every invention has to pass before becoming ripe for an industrial contest.

The starting point of the public experiments (the only ones that we shall here speak of, since they take in the laboratory researches made in the interim, and officially show the progress accomplished) dates back to the Exposition of Electricity of 1881. At that epoch Mr. Marcel Deprez, while submitting to the International Congress of Electricians his original views upon the transportation and distribution of energy, called upon the public to judge of the first practical application of his ideas at the Palace of Industry.

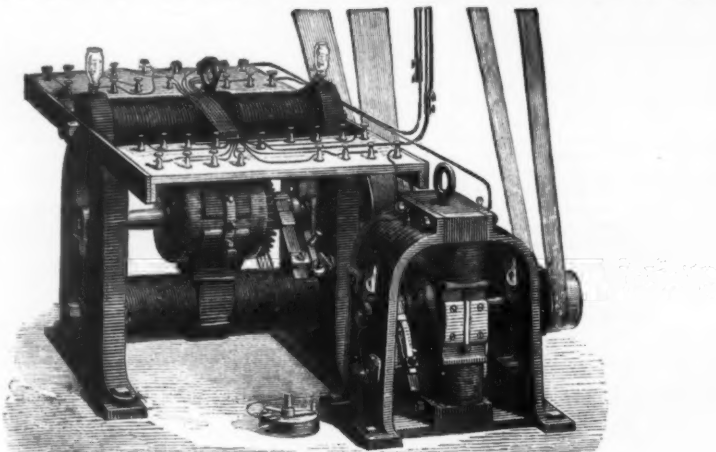


FIG. 1.—DEPREZ'S ELECTRIC GENERATORS.

As regards the distance of the transmission, the system offered nothing remarkable, the total length of the cable having been only about 5,500 feet; it was good, that was all. But where the inventor's merit and the truly original side of the installation appeared was in the process employed for distributing energy to a series of apparatus of different power that operated independently of each other. The regulation, in fact, was obtained without the aid of any mechanism, and was based upon an absolutely new principle—a double winding of the electro-magnets of the generating machine. This latter, as well as the machine that produced the constant exciting current, is shown in Fig. 1. These two machines were actuated by a gas motor of 4 horse power, and furnished a current for twenty-seven apparatus mounted on derived circuits in different parts of the Palace. These apparatus included arc and incandescent lamps, as well as a series of small motors that drove sewing machines, plaiting machines, ribbon saws, etc. All these small motors, excepting a Siemens machine that actuated a printing press, were magneto-electric ones of the Deprez type.

At that epoch but little attention was paid to the performance, a question which has now acquired a great importance, and so no measurements were made in that direction. The possibility of transporting and distributing power was for the first time established, and that seemed then to be a splendid enough result. For Mr. Deprez and his surrounders it was a beginning full of promise, but one at which he could not think of stopping. One particular point in the theories set forth by the inventor had been verified in a most brilliant manner, and it remained to experiment upon other points of these same theories, and especially upon all that concerned transmission to a great distance.

Mr. Deprez had declared that it was possible, by a proper modification of two identical Gramme machines of type C, to transmit an effective power of 10 horses to a distance of 30 miles by means of an ordinary telegraph wire, the initial motive power being about that of 16 horses. An occasion soon presented itself for verifying the fact experimentally. At the beginning of the year 1882, the technical commission having in charge the organization of the Munich Exhibition invited Mr. Deprez to set up a plant for the transmission of power to a distance of 30 miles, and put an ordinary telegraph line at his disposal as a conductor. The offer was too good to be refused. Just at that epoch there were at his disposal two Gramme machines of the workshop type, which had been so transformed as to give currents of high tension, and with which it had been found possible, in a laboratory experiment, to transmit 196 foot-pounds through an artificial resistance of 786 ohms (47 miles of telegraph wire), the performance being about 25 per cent. One of these machines was set up as a generator at Miesbach, and the other as a receiver at Munich, the distance between these two places being 45 miles. As a measure of prudence, it was judged necessary to effect the return through a second wire put up for the purpose, and not through the earth. Under such circumstances, the total resistance of the line was found to be 950 ohms.

The experiment was a success, although one of short duration. The modified and consequently imperfectly constructed machines, having been weakened by numerous laboratory experiments, and having been set up in haste, did not offer the qualities that were necessary to cause them to run with regularity.

Accidents occurred from the very first day, and soon entirely stopped the operation of the machines before it had been possible to make any accurate measurement. The certificate delivered by the commission reads as follows:

"The dynamo-electric machines were set in motion for the first time on the 25th of September, at 7 o'clock in the evening, and, according to data furnished by Engineer Datterer, who was appointed by the commission, revolved at the rate of 1,500 revolutions per minute. The brake that served to measure the work carried a load of 3 pounds.

"A series of accidents, due to the fact that the machines had been constructed for laboratory experiments, and not for practical use, stopped them at the end of eight days, although their running up to that time had been perfectly satisfactory. The hoops that encircled the ring of one of them broke, and the wires were consequently damaged and had to be insolated anew. In the distant town of Misebach such repairs could be made only with great difficulty, and required much

* From *La Lumière Electrique.*

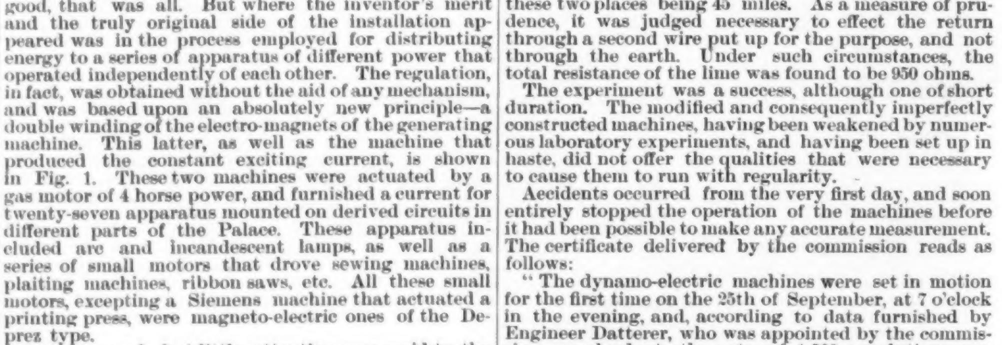


FIG. 2.—DEPREZ'S ELECTRIC GENERATOR.

patience and perserverance on the part of Mr. Deprez and his collaborators.

"On the 9th of October, when the committee on the experiments began its measurements, a velocity of only 1,600 revolutions per minute could be got out of the repaired machine at Miesbach; so the results were much less favorable than they would have been at the normal velocity of 2,000 revolutions that was attained at first.

"During the measurements, a velocity of 2,000 revolutions could be obtained for a few instants only; and again, at the beginning of the experiments, one of the brushes became detached, thus producing an extra current and completely destroying the machine."

Under disadvantageous circumstances such as these, the following were the results of the measurements:

Resistance of the line	950·2 ohms.
" " generator	453·1 "
" " receiver	453·4 "
Electromotive power of the generator at a velocity of 1,611 revolutions per minute....E=	1,578 volts.
Electromotive power of the receiver at a velocity of 752 revolutions per minute.........e=	614 "
Intensity	0·519 amp.

Effective electricity $= \frac{e}{E} = 0·389.$

As for the mechanical performance, that was estimated at 30 per cent. The work received at Munich was 25 H. P. measured at the brake; but to this should have been added the work absorbed through the vibrations of the machine, which had not a solid enough base. The work expended at Miesbach could not be estimated. In fact, the dynamometer used was one of Von Hefner-Alteneck's, constructed for measuring 15 horse powers, and, seeing the low power to be measured, the limits of error of the apparatus became too great to make it of any utility.

The Palace of Industry and Munich experiments that we have just mentioned demonstrated the possibility of transmitting and distributing power, although the economic aspect of the question remained in darkness. In both experiments the measurements were defective; but in those that followed, this matter was remedied, and the care that was taken with the measurements already allowed it to be seen that the question had assumed a new phase.

After the Munich experiments, the first in date were those performed on the 4th of March, 1883, at the shops of the Railway of the North, which the officers of the road had, for this purpose, kindly put at Mr. Deprez's disposal. This time the conditions were better, although not as good as could have been desired. The generator was a new machine, which had been especially constructed for the transmission of power, and which had given excellent results in some laboratory experiments. It consisted of two rings mounted in series (Fig. 2); and the magnetic field, formed of two horseshoe electros, was, at an equal expenditure of energy, much more powerful than in the former types constructed. As there was no time to construct a second machine of the same type, there was nothing to be done but again to take a transformed Gramme machine (type D) as a receiver. This machine, which was inferior to the generator as regards construction, had, moreover, been weakened by numerous laboratory experiments, and was subject, as was well known, to electric losses from defects that it was impossible to remedy in time for the experiment. In order to facilitate the measurements, the two machines were placed side by side. They were connected, on the one hand, by a short and but slightly resistant wire, and, on the other, by a galvanized iron telegraph wire, 0·15 inch in diameter, passing through Bourget, and having a total length of ten and a half miles. The total resistance was found to be 160 ohms.

Without entering into detail concerning the electric and dynamometric processes of measuring employed,

TABLE I.—DYNAMOMETRIC RESULTS.

Number of the experiment.	Revolutions per minute. Generator, N.	Revolutions per minute. Receiver, n.	Mechanical work. Furnished. By the pulley of the dynamometer, T.	Mechanical work. Furnished. At the generator, T m.	Mechanical work. Collected at the brake of the receiver, T u.	Mechanical work. Transmitted per revolution of the generator.	Dynamometric Performance. Gross $\frac{Tu}{T}$	Dynamometric Performance. Transmission deducted $\frac{Tu}{Tm}$
			H. P.	H. P.	H. P.	H. P.		
I.	378	104	3·838	3·296	0·578	0·00153	0·151	0·176
II.	370	38	3 854	3·331	0·489	0·00105	0·127	0·147
V.	850	602	9 771	7·665	3·344	0 00393	0·342	0·435
VI.	923	709	10·556	8·259	3·939	0·00427	0·372	0·477
VII.	850	643	9·514	7·408	3·572	0·00420	0·375	0·482
VIII.	1,024	799	12·267	9·731	4·439	0·00433	0·302	0·456

we shall sum up the results obtained. Table I. gives a *resume* of the dynamometric results; and upon an inspection of this we learn the striking fact that nearly 4⅙ H. P. was successfully transmitted, with a performance of 46 per cent., through a resistance of 160 ohms. Everything leads to the belief, moreover, that had the condition of the receiving machine permitted of giving the generator the greater velocity that it was capable of supporting, the work absorbed and that collected would have been much greater.

The results of the electric measurements recorded in Table II. likewise give rise to interesting conclusions. "The first result to be remarked in this table," wrote Mr. Cornu in his report, "is that the telegraph line has, during the transmission of power, with a current of about 2·5 amp., sensibly exhibited the 160 ohms resistance that was found in it with the 0·01 amp. current during the preliminary trials. This is shown in the column of effective resistances of the telegraph line, which were obtained by dividing the difference U—u (which represents the difference in potential at the ends of the line) by the intensity I. The mean of the results, 159·6, coincides with the many times determined figure 160.

TABLE II.—ELECTRIC RESULTS.

Number of the experiment.	Revolutions per minute of the Generator, N.	Revolutions per minute of the Receiver, n.	Intensity, I.	Difference in potential at the terminals of the Generator, U.	Difference in potential at the terminals of the Receiver, u.	Effective resistance of the telegraph line, $\frac{U-u}{I}$	Electromotive power in the Generator, E.	Electromotive power in the Receiver, e.	Effective electricity, $\frac{e}{E}$
			amp.	volts.	volts.	ohms.	volts.		
I.	378	104	2·39	722	321	167·0	855	116	0·136
II.	370	88	2·52	745	355	155·0	888	138	0·155
VI.	923	709	2·52	2,086	1,685	159·0	2,229	1,468	0·658
VII.	850	643	2·57	1,937	1,479	179·0	2,038	1,258	0·604
VIII.	1,029	799	2 50	2,338	1,994	138·0	2,480	1,779	0·717
Mean val						159·6			

"The divergence of the partial results is due to the inevitable oscillations in the velocity of the machines, and especially to the impossibility of making absolutely simultaneous measurements of U, u, and I.

"This identity between the effective resistance of the line and the measured resistance is very important, from the standpoint of accordance between theory and experiment, for the analysis of the phenomena of transformation of energy in the circuit. It shows that the consumption of energy necessary to get over the resistance of 160 ohms is practically exactly equal to the value foreseen by theory. This quantity of energy expressed in kilogrammeters per second is equal to $\frac{\rho I^2}{g}$ and in horse power $\frac{\rho I^2}{75 g}$. As the intensity of the current remained sensibly constant, and equal to 2·5 amp., the loss of mechanical work was equal during the entire series to about:

$$\frac{160 \times \overline{2·5}^2}{75 \times 9·81} = 1,358 \text{ H. P.}$$

"This quantity of energy is, as well known, disseminated under the form of heat.

"Another result conformable to theory is the proportionality of the electromotive forces to velocity, the intensity remaining constant. If, in fact, we calculate the quotients $\frac{E}{N}$ and $\frac{e}{n}$, we find:

	Experiments. I.	II.	VI.	VII.	VIII.
Generator $\frac{E}{N}$	2·26	2·40	2·41	2·45	2·42
Receiver $\frac{e}{n}$	1·12	1·57	2·07	1·96	2·23

"For the generator, the proportionality is very satisfactory; and for the receiver it becomes so in the experiments in which the velocity, n, was well measured."

In short, the experiment fully proved the theories put forth by Mr. Deprez before the Congress of Electricians.

The next experiment was performed at Grenoble. This town, which is situated in the center of a mountainous country, possesses in its environs a large number of waterfalls—natural sources of power which, up to this day, are not much or at all utilized; and it would be one of the first to find a great advantage in a realization of the transmission of power. So the mayor, who was particularly anxious to have a clear knowledge of Mr. Deprez's experiments, invited him to come to Grenoble to pursue them, and put at his disposal conditions that were absolutely analogous to those that would be presented in practice. Mr. Deprez accepted, well knowing that it would positively be but a repetition of what had just been done at the shops of the Railway of the North. But, aside from the fact that two confirmations are worth more than one, he had had time to repair the receiver, and especially to improve its magnetic field, and, moreover, he was about to find himself in a position to combat an argument which was used against his railway experiments, and which was drawn from the fact that the machines were placed side by side. He was to repeat himself, it is true, but the repetition was to be made under better conditions; and the results would this time be irrefutable.

The same machines were arranged, one, as a generator, near Vizille, 8½ miles from Grenoble, and the other, as a receiver, in the center of the town, in an old building fitted up for the purpose. The generator was actuated by a turbine that made 140 revolutions per minute. In order to pass from this velocity to that of the dynamo, nearly ten times greater, it was necessary to have recourse to a series of shafts. The line, which consisted of two silicious bronze wires, 0·08 in. in diameter, had a resistance of 167 ohms. Its condition of insulation was very ordinary—rather bad than good.

A committee of engineers, under the chairmanship of Mr. P. Boulanger, was appointed to watch the experiments and make the electric and dynamometric measurements.

The dynamometric results are seen in Table III., and show that with the same machines, and these in line, nearly 7 H. P. was successfully transported with a performance of 62·3. The measurements made at Grenoble not only fully confirmed the results obtained in the shops of the Railway of the North, but again justified the opinion given by Mr. Cornu in the above cited report, to wit, that the performance would have been higher had the receiver been in better condition. If we consider the last experiments as being those in which the measurements offer the best guarantee, and compare these with those of the preceding experiments, we shall find that in the latter the ones numbered V., VI., VII., and VIII. show the mean performance to have been equal to 0·462, while in the Grenoble experiments the mean was 0·515.

TABLE III.—DYNAMOMETRIC RESULTS.

Dates of the Experiments.	Number of the Experiments.	Number of revolutions per minute of the Generator, N.	Motive power, less Transmission, T_m.	Number of revolutions per minute of the receiver, n.	Work received, T_u.	Performance $\frac{T_u}{T_m} \times 100$
			H. P.		H. P.	
August 22, 1883.	A 1	724	5·79	604	2·75	47·5
	A 2	726	6·52	540	3·07	47·0
	A 3	726	7·85	488	3·33	42·4
	B 1	810	7·25	641	3·65	50·3
	B 2	817	8·37	590	4·03	48·1
	B 3	807	9·06	535	4·26	47·0
	B 4	832	14·40	504	4·59	44·1
	C 1	936	....	758	4·31	....
	C 2	915	8·03	684	4·67	58·1
	C 3	906	8 81	622	4·95	56·2
	C 4	906	10·18	591	5·38	52·8
	D 1	950	9·97	646	5·88	58·9
	D 2	962	12·27	618	6·33	51·6
August 28.	E 1	896	9·55	636	5·06	52·9
	E 2	980	10·91	700	5·57	51·1
	E 3	990	14·57	690	6·28	43 1
	E 4	1,000	15·47	638	6·53	42·2
	E 5	985	15·60	584	6·64	42·6
	E 6	1,040	.....	763	6·07	....
	E 7	1,060	.....	733	6·65	....
	E 8	1,056	11·50	673	6·89	59·9
	E 9	1,014	11·95	608	6·92	57·9
September 1.	H 1	720	6·97	484	3·30	47·3
	H 2	730	8·20	446	3 55	43·2
	H 3	732	8 96	406	3·69	41·1
	K 1	865	8·33	614	4·19	50·3
	K 2	865	9·82	586	4·66	47·4
	K 3	875	11·05	558	5·08	45·9
	L 1	946	8·42	712	4·86	57·7
	L 2	954	10·10	386	5·46	54·0
	L 3	970	11·46	662	6·02	52·5
	M 1	1,040	9 69	830	5·66	58·3
	M 2	1,040	11·08	778	6·19	55·8
	M 3	1,050	12·33	734	6·68	54·1
	N..1	1,140	11·18	875	6·97	62·8

TABLE IV.—ELECTRIC RESULTS.

Dates of the Experiments.	Number of the Experiments.	Mean Intensities, $\frac{I+i}{2}=I_m$.	Number of Revolutions per minute of the Generator, N.	Number of Revolutions per minute of the Receiver, n.	Electromotive power of the Generator, E.	Electromotive power of the Receiver, e.	Electric Performance, $100 \times \frac{e}{E}$
		amp.			volts	volts	
August 22, 1883.	A 1	2·25	724	604	1,788	1,066	59·6
	A 2	2·43	726	540	1,873	1,093	58·3
	A 3	2·90	726	488	2,018	1,087	53·8
	B 1	2·59	810	641	2,163	1,332	61·5
	B 2	2·77	817	590	2,239	1,350	60·3
	B 3	3·07	807	535	2,292	1,307	57·0
	B 4	3 26	832	504	2,413	1,367	56 6
	C 1	2·45	936	758	2,424	1,638	67·5
	C 2	2·70	915	684	2,480	1,613	65·0
	C 3	2·98	906	622	2,555	1,598	62·5
	C 4	3·25	906	591	2,626	1,584	60·3
	D 1	3·20	950	646	2,736	1,709	62·4
	D 2	3·46	962	618	2,848	1,737	60·9
August 28.	E 1	3·02	896	636	2,536	1,567	61·7
	E 2	3·01	980	700	2,773	1,807	65·1
	E 3	3·22	990	690	2,861	1,828	63·8
	E 4	3·47	1,000	638	2,960	1,846	62 3
	E 5	3·72	985	584	2,985	1,791	60·0
	E 6	3·05	1,040	763	2,954	1,975	66 8
	E 7	3·33	1,060	733	3,106	2,037	65 2
	E 8	3·53	1,056	673	3,147	2,014	63·9
	E 9	3·78	1,014	608	3,083	1,870	60·6
September 1.	H 1	2·60	720	484	1,922	1,087	56·5
	H 2	2·85	730	446	2,022	1,107	54·7
	H 3	3·10	732	406	2,094	1,099	52·5
	K 1	2·58	865	614	2,301	1,473	64·0
	K 2	2 82	865	586	2,387	1,482	62·0
	K 3	3·08	875	558	2,494	1,505	60·3
	L 1	2·60	946	712	2,516	1,681	66·8
	L 2	2 84	954	686	2,633	1,721	65·3
	L 3	3 12	970	662	2,774	1,772	63·8
	M 1	2·64	1,040	830	2,787	1,940	69·5
	M 2	2·86	1,040	778	2,891	1,973	68·2
	M 3	3·15	1,050	734	2,992	1,981	66·2
	N..1	2·85	1,140	875	3,146	2,231	70·8

Table IV. gives a summary of the electric measurements made at the same experiments. The third column of this table contains the means of the intensities measured at Vizille (I) and Grenoble (i). It had often been asserted that with high electromotive powers, losses through the line would not fail to become very great; and so it became necessary to ascertain the extent of such losses experimentally. The readings of

the intensity made at Grenoble and Vizille at each experiment, with a Deprez fish-bone galvanometer, had already permitted it to be seen that these losses were small enough to allow the mean intensity to be considered in the calculation both for the generator and receiver without inconvenience. It more than once happened, in fact, that the intensity found at Grenoble was greater than that at Vizille, thus indicating for the differences in intensity magnitudes of the same order as the errors in reading.

It was nevertheless deemed well to perform two accurate experiments; and these it is proper to recall, since the results thereof establish the fact that, even with great differences in potential, the losses through the line are extremely small.

These experiments were made by means of nitrate of silver voltameters. In the first, with a difference of 2,627 volts at the terminals of the generator, an intensity of 3·268 amp. was shown at Vizille and 3·099 at Grenoble, which represents a loss of 5·1 per cent. In the second, the difference in potential was 2,934 volts, and the intensities at Vizille and Grenoble were respectively 3·514 amp. and 3·282 amp., representing a loss of 6·6 per cent.

The measurements made at Grenoble verified, too, some other theoretical statements. Mr. Deprez had shown that when magnetic fields reach the limit of saturation the load at the brake is proportional only to the first power of the intensity. We have, in fact, in a general way, in a perfect Pacinotti machine,

$$fv = eI,$$

where f designates the resultant of the elementary electro-dynamic actions that occur between the inductors and ring, v the velocity of the point of application of such resultant, e the electromotive power of the

TABLE V.

Number of the Experiment.	Loads on the Grenoble brake.	Mean Intensities.
		amp.
A — 2	11 lb.	2·43
B — 1		2·59
C — 1		2·45
A — 3	13 lb.	2·00
B — 2		2·77
C — 2		2·70
H — 1		2·60
K — 1		2·58
L — 1		2·60
M — 1		2·64
B — 3	15½ lb.	3·07
C — 3		2·98
H — 2		2·85
K — 2		2·82
L — 2		2·84
M — 2		2·86
N — 1		2·85
B — 4	17½ lb.	3·26
C — 4		3·25
D — 1		3·20
H — 3		3·10
K — 3		3·08
L — 3		3·12
M — 3		3·15

motor, and I the intensity of the current; whence

$$f = \frac{e}{v} \mathrm{I}$$

Now, as in the case of the saturation, $\frac{e}{v}$ is constant, we have $\frac{f}{\mathrm{I}}$ = constant. This relation is verified by Table V., which is taken from Nos. I. and II.

On the occasion of these experiments, a few were made on distribution; but as this had not been contemplated in the programme, there was scarcely the proper equipment available for operating the current of high tension furnished by the Vizille machine. It was decided to repeat what had been done at the Exposition of 1881, but in this case to make measurements. The generator was a Gramme electro-metallurgic machine, the inductors of which had been re-enforced and doubly wound. A small Gramme machine, serving as an exciter, furnished the constant current designed to traverse the second winding. These two machines were actuated by an engine that kept up the proper velocity to cause the generator to give a constant difference in potential at the terminals.

The receivers were five in number—two Gramme machines of the workshop type and three small Siemens machines. From the terminals of the generator started two parallel cables, which passed in front of the receivers placed side by side. Opposite each machine branched secondary conductors from the main cables. As these latter were short and formed of doubled copper wire, their resistance did not have to be taken into account, and all was as if the derivations had been taken at the terminals of the machine. As for the derived circuits, their resistances were solely those of the machines, distributed as follows:

Receiver No. 1	Gramme Machine..	$r_1 = 1·25$	ohm.
" No. 2	" "	.. $r_2 = 1·09$	"
" No. 3	Siemens "	.. $r_3 = 0·622$	"
" No. 4	" "	.. $r_4 = 1·307$	"
" No. 5	" "	.. $r_5 = 0·615$	"

As in the case of the experiments on transmission, the measurements made here were electrical and dynamometric, and the results of them are given in Tables VI. and VII.

After these numerous experiments, one point still remained to be cleared up, and that was whether it was possible to transport high powers to a distance; that is to say, whether it was possible to practically employ very high tensions. It belonged to the civil experiment to pronounce upon this unknown problem,

TABLE VI.—DYNAMOMETRIC RESULTS.

Number of the Experiments.	Number of Revolutions per minute of the Generator.	Receiver No. 1. Number of Revolutions per minute.	Receiver No. 1. Work per Second.	Receiver No. 2. Number of Revolutions per minute.	Receiver No. 2. Work per Second.	Receiver No. 3. Number of Revolutions per minute.	Receiver No. 3. Work per Second.	Receiver No. 4. Number of Revolutions per minute.	Receiver No. 4. Work per Second.	Receiver No. 5. Number of Revolutions per minute.	Receiver No. 5. Work per Second.	Observations.
			Foot-pounds.		Foot-pounds.		Foot-pounds.		Foot-pounds.		Foot-pounds.	
1	2,230	540	130·5	...	.....	.....	...	.....	.....	.....	...	The total work in the last experiment is 1967·2 foot-pounds.
2	2,270	568	137·0	590	142·0	.....	...	.....	.....	.....	...	
3	2,238	560	134·6	584	141·4	1,276	308	.....	.....	.....	...	
4	2,238	528	127·6	572	138·5	1,200	290	1,184	286·4	.....	...	
5	2.169	557	134·0	562	135·6	1,200	290	1,031	251·6	1,060	256	

TABLE VII.—ELECTRIC RESULTS.

Number of the Experiments.	Number of Revolutions per minute of the Generator.	Deflection of Galvanometer No. 3 Δ	Difference in Potential at the Terminals of the Generator. $U = 2·6 = D$	Deflection of Galvanometer No. 2 δ	Difference in Potential at the end of the line. $u = 6·74 \times \delta$	Receiver No. 1. Deflection of Galvanometer No. 1 : d_1	Receiver No. 1. Intensity. $d_1 \times 0·7 = i_1$	Receiver No. 2. Deflection of Galvanometer No. 1 : d_2	Receiver No. 2. Intensity. $d_2 \times 0·7 = i_2$	Receiver No. 3. Deflection of Galvanometer No. 1 : d_3	Receiver No. 3. Intensity. $d_3 \times 0·7 = i_3$	Receiver No. 4. Deflection of Galvanometer No. 1 : d_4	Receiver No. 4. Intensity. $d_4 \times 0·7 = i_4$	Receiver No. 5. Deflection of Galvanometer No. 1 : d_5	Receiver No. 5. Intensity. $d_5 \times 0·7 = i_5$	Total Intensity. I
		deg.	volts.	deg.	volts.	deg.	amp.	deg.	amp.		amp.		amp.		amp.	
1	2,230	15·15	39·4	5 80	39·1	13·90	9·7	.....	....	.....	....	.....	...	.....	....	9·7
2	2,270	15·00	39·0	5·75	38·8	14·10	9·9	16·20	11·3	.....	....	.....	....	.....	....	21·2
3	2,238	15·10	39·3	5·80	39·1	14·10	9·9	16·15	11·3	25·15	18·3	.....	....	.....	....	39·5
4	2,238	15 00	39·0	5·75	38·8	14·20	9·9	16 40	11·5	25·00	17·5	27·20	19·0	.....	....	57 9
5	2,169	15·05	39·1	5·80	39·1	13·60	9·5	15·20	10·6	24·50	17·2	26·50	18·6	27·50	19·3	75·2

which is a very formidable one in the eyes of a large number of electricians. When these lines make their appearance, the experiment will scarcely have been begun for the public, but for us it has already been made. Through a copper cable 0·2 inch in diameter and 67 miles in length, 40 H. P. was transmitted with a mechanical performance of 50 per cent. In this experiment the generator made 170 revolutions per minute, and, with this feeble velocity, developed an electromotive power of very nearly 6,000 volts. These results need no comment.

The complete results of the electric and dynamometric measurements made upon the Creil and Paris machine will form the subject of a succeeding article.

MELSENS' LIGHTNING RODS.

THE accompanying engravings, from *La Lumiere Electrique*, show the arrangement adopted by Mr. Melsens for protecting the Hotel de Ville of Brussels against lightning.

Fig. 3 represents the apex of the spire, crowned by a statue of Saint Michael trampling upon Lucifer. This statue, which is of gilded copper, performs the role of a weather vane, and rests upon an iron axle, A, which enters the stone masonry to a great depth. Contact between the statue and bar is well established through

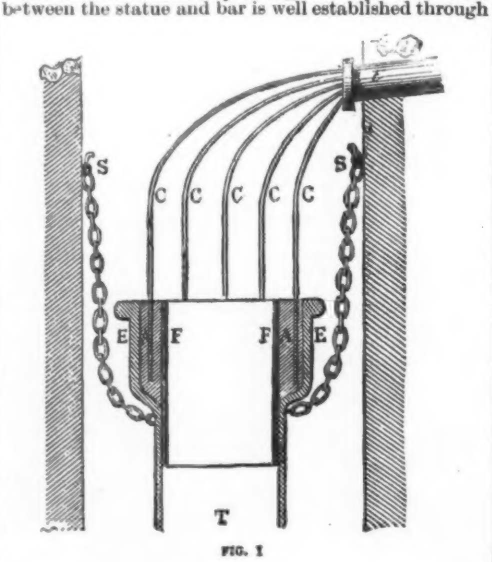


FIG. 1

the wear due to continual friction. A stay, B B, with four rods, $t\,t$, prevents all lateral or vertical motion. The entire apex, from the bolted ring, D D, as far as to G G, is covered with sheet copper, which is tinned at H I. This copper is itself covered from D D to F F with sheet lead fixed to the axis by the bolted ring, D D. This prevents infiltrations of water between the pivot and the sheet copper. Eight conductors (C—C) of galvanized iron, ⅜ in. in diameter, are connected metallically with the pivot, A. This latter, which is well smoothed by filing, and the eight conductors, which are perfectly tinned, are embedded in zinc, which was poured around them in a molten state. In this way a perfect contact was obtained between the pivot and all the conductors. Around one of the projections of the capstone runs a tinned iron hoop (K—K), in which are adjusted eight rods (P—P), 6½ feet in length, ¾ in. in diameter at the base, and terminating in copper points, which are fire-gilded for a length of 8 inches. These rods are connected with the conductors by means of a mass of zinc, M, which was poured upon the iron hoop in a molten state.

Between this hoop and the sheet copper that covers the apex of the tower there was poured about 220 lb. of molten zinc (Z). Eight rods (T — T), soldered on the one hand to the point, and on the other to the sheet copper, hold and consolidate the eight large points. Where each rod comes into contact with a conductor, there is placed an aigrette formed of five points of copper 19½ inches in length. Each aigrette is fixed upon the rod, T, the conductor, C, and a supplementary support, S, by means of a mass of zinc (m), which unites all of them. This entire affair, that is to say, the statue, the pivot, the 40 points, and the 8 conductors, forms an absolutely solid metallic whole, under the form of a large aigrette having an annular space of about 16 feet in diameter between the extremity of the two large opposite points.

Fig. 1 represents the communication of the conductors with the wells. The eight conductors (C — C) enter through the iron tube, t, and are fixed in a cast

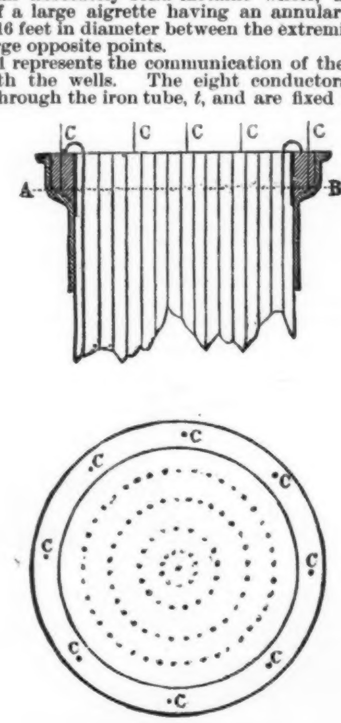


FIG. 2

iron pipe, T, 9 feet in length and 24 inches in diameter. In order to fix the conductors, the interior of the neck, E E, is tinned, and a cylinder, F F, of strong iron plate is introduced by friction into the body of the pipe, and thus forms an annular space, A A, between it and the neck, E E. It is into this space that are introduced the tinned ends of the eight conductors, which are surrounded by zinc that was run in in a molten state.

The pipe, T, is buried 10 feet beneath the surface of the earth, and is held by means of chains fixed to two iron bars that traverse the masonry at S S. There is a contact with water over a surface of about ten square yards, reckoning the two surfaces of the hollow cylinder.

The idea of placing a number of long iron wires in the pipe was given up, and it was decided to merely insert 20 ordinary iron ones, ending in points 16 feet in length and one-third of an inch in diameter, and soldered in groups of two or three to the light conductors (C — C), the soldering being afterward sur-

rounded by a mass of lead (Fig. 2). Moreover, to each of the light conductors there is soldered a conductor one-third of an inch in diameter that communicates through a metallic contact embedded in a block of retort carbon, 3¼ ft. long by 2 wide. All these contacts together present a surface of more than twenty-four square yards.

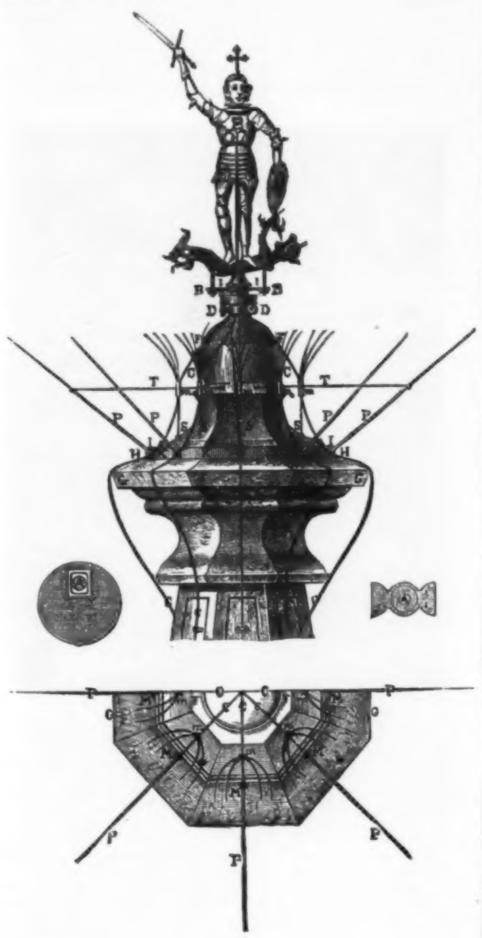
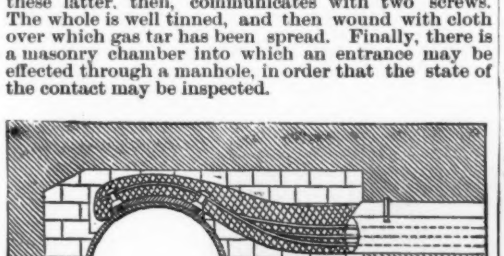


FIG. 3

The pipe that leads the conductors to the water and gas mains is a semi-cylinder of cast iron provided with a cover. The conductors are placed in this, and the pipe is filled with coal-tar pitch to prevent rusting (Fig. 5). Fig. 4 shows the mode of communication of the conductors with the system of gas pipes. To the gas pipe, after its surface had been well cleaned, was soldered, by means of tin, a sheet of copper one-third of an inch thick and 1½ inch long, in which are adjusted 16 brass screws with strong heads containing an aperture for the passage of the conductors. Each of these latter, then, communicates with two screws. The whole is well tinned, and then wound with cloth over which gas tar has been spread. Finally, there is a masonry chamber into which an entrance may be effected through a manhole, in order that the state of the contact may be inspected.



Plan

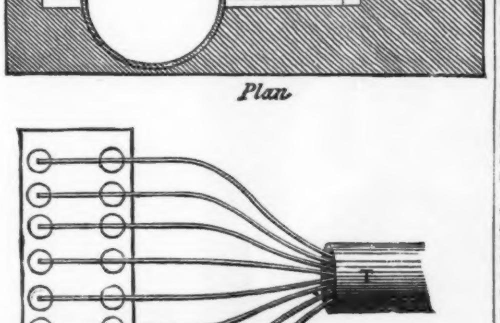


FIG. 4.

The junction of the conductors with the water main was made as follows (Fig. 6): For want of enough galvanized iron wire ⅓ in. in diameter, it became necessary to use wire about half that size. So, in order to obtain perceptibly the same total section for each of the three series, it became necessary to employ twenty wires instead of eight in order to carry out this idea. The three series of subterranean conductors, then, have a total section of about 26 square inches, three times that of the 8 conductors of the main aerial lightning rod. The water main used is 20 inches in diameter and ½ inch in thickness.

To the previously well cleaned surface of the water pipe is affixed by means of 8 screws, *t*, a sheet of copper ½ an inch thick, 20 inches long, and 12 inches wide, which is likewise soldered and tinned at the edges. The 21 conductors are affixed to this plate by means of

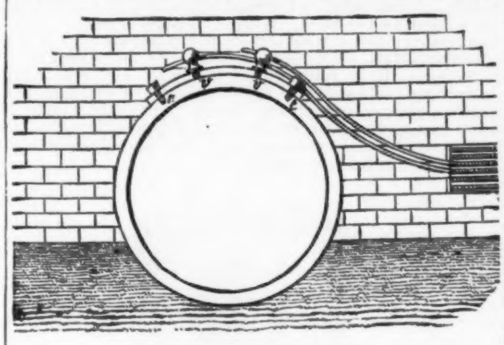


FIG. 5.

brass screws, V, with strong heads containing an aperture for the passage of the conductors. The whole is tinned and wrapped with tar-covered cloth.

Finally, there is a masonry chamber in which men can move with ease, and in the center of which is placed the tube. By this means it can always be easily seen whether the entire system is in a proper state.

It has been seen (Fig. 4) that 417,650 square yards is

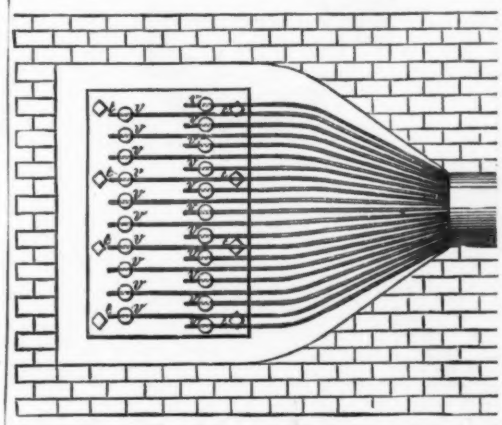


FIG. 6.

given for the surface of contact of the two systems of piping. The exact figures are as follows:

Internal surface of the water mains	169,976	sq. yards.
External surface	192,344	"
" " of gas mains.	156,465	"
Total	527,785	"

ROSOLENE.

THIS product, otherwise known as retinol, $C_{32}H_{16}$, is obtained by the dry distillation of resin. It is in appearance like the oil of sweet almonds. It is insoluble in water and alcohol, soluble in ether, the essential oils, and carbon disulphide. It mixes perfectly with the fatty oils in all proportions, but it is incapable of saponification or of turning rancid.—*Emile Serrant, in Comptes Rendus.*

ATOMS AND MOLECULES.*

THE ultimate constitution of the material world has engaged the attention of philosophers of all ages. The ancient school considered that matter was composed of four original elements—earth, water, air, and fire. The precise conception they had concealed behind these words we know not. But it is very remarkable that the division as an analogy corresponds closely with modern theory. In our recognition of the solid, liquid, and gaseous states of matter may be found a parallelism with their conception of elemental earth, water, and air, and the elemental fire may be taken as representing our theoretical luminiferous ether.

While the subject of the material of the world was disposed of, the ultimate division of this material was also discussed. The problem was this: If matter of any kind be divided and redivided until further breaking up of the mass is impossible, until the smallest particle that can exist is reached, what is the constitution of this final and indivisible mass? This has been a theoretical question until within the last few years, when, thanks to the labors of such men as Clausius, Sir William Thomson, and Clerk Maxwell, an element of practicality has been introduced into it. The old philosophers named this particle the atom or "*indivisible.*" Four general theories of it may be cited. The school of Leibnitz and Boscovitch treated it as a simple point of no magnitude. Kant and the transcendental school considered it a center of attractive and repulsive forces. The atomic school, including most modern chemists, consider the atom as a primitive and non-composite mass of matter. The fourth school, trying to blend the ideas of the last two just given, say that the atom is composed of matter and form; using these words in the most abstract sense.

All this applies to the old atom. In modern science this has been supplanted by a new unit, the molecule. In the language of to-day, the atom has a new meaning. We assume that the possibility of dividing matter stops with the molecule. Going a step further, we believe that the molecule is itself composite, and composed of two or more elemental atoms. The reduction of matter below the molecular division is inconceivable. Complex molecules may be broken up into simpler ones, but the final result will always be a collection of molecules. Were matter reduced to the atomic state, to being a mere aggregation of atoms, theory can give us not even a hint of what would happen. Those who are fond of tracing analogies and of finding a kernel of truth in old theories may accept the fourth theory of atoms just given, and treat the molecule as a compound of matter and form, of atoms arranged in existible order.

As our working theory this evening, we may accept the plain atomic view. Matter consists originally of elemental atoms, of exceedingly small dimensions, that in all matter as we know it are grouped into molecules.

In a general sense, atoms may be called the units of chemistry, and molecules the units of physics. Where we recognize a chemical change in matter, we generally believe that the atoms have undergone some alteration in their grouping. In physics we deal with molecular changes alone. The moment the constitution of the molecule is interfered with, and its constituent atoms caused to shift or alter, a chemical change is held to have taken place. Such change generally involves a new grouping of the atoms.

We live in an atmosphere, one-fifth of whose volume is an elemental gas known as oxygen. This gas we know cannot by any means in our possession be divided into other substances, and therefore we term it an element. In the metals we have other elements. I have here a bundle of flattened wire or metallic ribbon, composed of the metal magnesium. When heated in the air, it takes fire and burns with a dazzling, bluish-white light. The mere fact of the production of so much heat and light almost proves a chemical change. But we shall collect the products of the process, and examine them. They consist of a snow-white powdery substance resembling chalk—quite the opposite of the lead-colored metal we started with. If we had weighed one wire and then had weighed this product, we should have found that for every twenty-four parts of magnesium we have forty parts of the new product. This means that we have united several things. On separating the product into its constituent parts as far as we are able, we find that it is composed of twenty-four parts of the metal magnesium and sixteen parts of the gas oxygen. Our chemical forces can go no further. Therefore we say that this white powder is a chemical compound of magnesium and oxygen, and that these substances are elements. The burning of the wire we call a synthesis, or putting together; the determination of the constituent parts of the compound we call an analysis, or unbinding.

Recurring to the atomic and molecular theories, what we did in our synthesis of magnesia was this: We heated a collection of molecules of magnesium in contact with a collection of molecules of oxygen. A chemical change took place. The molecules entered into combination atom by atom, an atom of oxygen combining with an atom of magnesium, but the atom as such never existing alone.

There I used heat to effect a synthesis. I shall now use electricity to effect an analysis. If a current of electricity is passed through water that has been made a conductor by the addition of some salt or other substance, the water will be split up, or decomposed, into two gases. By passing such a current through the vessel of acidulated water that is before you, the decomposition is very visible. A cloud of bubbles rise from the two platinum plates the moment I connect the battery wire or close the circuit. By filling two tubes open at one end with water, and inverting them still filled over the plates, I can collect the gases thus evolved, each gas in its own tube. I do so, and we notice that more gas comes off at one electrode than at the other. Furthermore, on measuring the gases we shall find that precisely twice as much of one as of the other is set free. The smaller quantity of gas we find on examination to be some oxygen, the other to be some hydrogen. We have no means sufficiently powerful to split up either of these gases. We can make nothing out of them but oxygen and hydrogen. Therefore we say that water is a compound of hydrogen and oxygen, two volumes of the first to one of the second, and that hydrogen and oxygen are elements.

Now, a very important law in chemistry of the last twelve years is that relating to the volumes of atoms and molecules in the gaseous state. As a theory it is much older, but has only recently been made the basis of chemistry. It is called Avogadro's law. It affirms that the volumes of all molecules in the gaseous state are equal. Therefore we at once perceive the atomic or chemical constitution of water; it consists of molecules, each molecule containing two atoms of hydrogen and one of oxygen.

Thus we have studied the mutual reactions of three elemental substances. By examining all terrestrial materials, between sixty and seventy of such substances or elements have been discovered.

We should not do right if we considered these sixty odd elements the successors of the four ancient elements. These four are rather physical elements. Chemistry is most accurately placed as a modern science, quite unknown to the ancients save in a practical way. They formulated no theory that we know of.

We have seen two representative chemical or atomic changes. In one, a metal and a gas were permanently combined so as to produce a white powder. In the other, water was decomposed, producing two gases. One indication of a chemical change is a permanent alteration. In a molecular change, as a rule, the body so changed will return to its original state, the disturbing cause being removed or the original status being restored. I have here a flask a third full of water that has been boiling for some time. The flask has a long tube projecting from its neck up into the air. By the application of heat I have brought about a physical or molecular change. I have converted the liquid water into perfectly invisible, gaseous steam. The flask is full of it, and it is pouring out of the top of the tube. I can prove its presence by holding some indicators over the open end of the tube. Anhydrous sulphate of copper is a white substance that is turned blue by water. The escaping steam colors it blue, as you see. The flask, I have said, is full of steam. You see nothing, and might say that it is air. But on invert-

* A lecture delivered by T. O'Conor Sloane, Ph.D., before the Young Men's Institute, Dec. 22, 1885.

ing it, and placing the end of the tube in water, we find that the flask rapidly fills. It could not do this if it contained air. The gaseous steam turning again into water creates a vacuum, and the atmospheric pressure drives the water up into the flask in opposition to the force of gravity. Coming down to quantities, we find that in round numbers a cubic inch of water produces a cubic foot of steam.

The water, which as you remember we have analyzed, is a collection of molecules. Now, as water is slightly compressible, we believe that the molecules are not in contact with each other. We believe that they have repulsive and attractive force; that in water the forces nearly balance, with a slight preponderance of the attractive. By the application of heat we turn the scale, and develop the repulsive forces to such an extent as to drive the molecules asunder, to twelve times their original distance, and produce steam, a pure gas.

We do not, however, conceive of these molecules as quiescent bodies situated at greater or less distances from each other. We consider them as highly elastic and in a perpetual state of motion, flying back and forth in all directions, continually colliding with each other, and in the case of liquids and gases continually traveling throughout the limits of the space filled by them. A vessel containing a quantity of fine shot in violent agitation gives some idea of it. The collision of ivory balls has been invoked to illustrate the encounter, as it is now technically called, of molecules, but Clerk Maxwell prefers to regard the encounter as a period of some duration. He assigns to it a finite space of time, during which the centers of the molecules first approach and then recede before the molecules part company. In solids, owing to the great development of the cohesive force, the molecules are greatly restricted in their freedom of motion; they vibrate with intense energy, but never travel out of a limited orb.

As gas always tends to expand, if air is confined in a weak vessel or flask, and the air surrounding it is removed, the flask will burst. This is due not to a quiescent swelling of the gas contained, as the gas is unchanged in all respects until the explosion. It is due to the bombardment of the walls of the flask by the gaseous molecules contained within it. While surrounded by air, this, too, bombarded the outer walls, and so resisted the rupturing strain.

I have said that in liquids and gases the molecules travel about through the whole mass, while in solids they do not. The proof of this migration is found in the phenomena of diffusion. If two liquids of different specific gravity, and invisible with one another, are placed in a vessel, the lighter floating on top of the heavier, they will eventually mix, no matter how quiet the vessel is kept. The action takes place at the separating planes or surfaces. If the mixture is stirred, a few seconds will effect the result. Otherwise, days may be required. The interlaced veins of the mixing liquids can be seen on looking through the fluid during the stirring process. The action of stirring is effectual simply by increasing the surfaces of contact and so accelerating the diffusion. Agitation by itself would not mix the liquids for an indefinite time, were it not for the diffusion among the molecules. It would reduce them to a collection of fine veins, very like vermicelli. Diffusion of liquids comes into play in every-day life. The mixing of tea and coffee with milk and heavy sugar solution are due to diffusion. Without this natural action to help us, we would have hard work to perfectly blend the fluids.

The fact that a trace of any solution will thus travel and distribute itself through a large volume of liquid is one proof that the molecules of a homogeneous fluid keep traveling about. In an undisturbed glass of water, or in the ocean in its deadest calm, the molecules of water are incessantly in motion through the mass.

In solids there is no diffusion, in liquids it is comparatively slow, in gases it is rapid. I have here two glass jars. The inverted jar contains a light gas, ammoniacal gas, a compound whose molecules each consists of three atoms of hydrogen with one of nitrogen. The next jar, standing on its bottom, contains a heavy gas, hydrochloric acid, whose molecule contains one atom of chlorine and one of hydrogen. Now, on placing the ammonia jar mouth downward on top of the other one, the heavy gas travels up, the light gas travels down, and the two mix, although in opposition to their relative gravities. The ocular evidence of their mixing is found in the white cloud they form when they come together. The cloud is solid ammonium chloride.

Now, not only do gases possess this property of molecular travel, but they possess it in different degree. The lighter gas travels the fastest. This is proved by analysis, and can be shown very strikingly by the use of a porous cup. The end of a vessel made of porous porcelain or of pipe clay is closed, and a glass tube is connected thereto so as to communicate with the interior of the cup. The end of the tube is placed in a beaker of water, and a vessel full of a light gas is inverted over the cup. The air inside tends to travel out of it; the light gas, in this case hydrogen, tends to travel into it. The lighter gas travels the fastest; it goes into the cup faster than the other travels out, and occasions an increase of pressure, rendered manifest by the rapid explosion of bubbles of air and gas at the bottom of the tube. On removing the vessel of hydrogen, we reverse matters. The lighter gas is now inside. It escapes faster than air can enter, and the water rises in the tube, owing to the production of a partial vacuum. The action of the porous vessel is peculiar. It acts as a molecular sieve, permitting the passage of molecules, but cutting off currents of gas. Instead of the open-ended tube immersed in water, a soap bubble may be blown by diffusion, and serves as the indicator of the action (Fig. 1).

The length of the paths through which the molecules vibrate varies with the pressure. If we inclose a little gas in a tube open at its lower end, and immerse that end in mercury, we can vary the volume of the gas by varying the pressure. If we lower the tube into the mercury, the gas shrinks; if we raise the tube, it expands. This contraction and expansion are due to alterations in the length of path of the vibrating molecules.

The paths of the molecules are affected in like manner by heat. If we heat a gas, we cause the paths to grow longer, if the gas is free to expand. If not free to do so, we make the molecules beat harder against the walls of the containing vessel. This is more simply stated by affirming that the volume of gas free to expand is increased by heat, and diminished by cold; that if the gas is contained in a tight vessel, its pressure increases when heat is applied, and diminishes when heat is abstracted. The same law in general terms applies to solids and liquids.

This fixed and invariable relation between the energy of molecules and the heat present leads us to the modern theory of heat, namely, that this motion of the molecules is heat, and that all bodies are in a perpetual state of molecular or thermal vibration, and that heat is a species of motion. When this motion ceases, then, and then only, do we reach the absolute zero of the thermometric scale. In practice this has never been attained. It is represented by —273° C. What the condition of bodies at this temperature would be is a pure matter of conjecture. According to our definition and conception of heat, no lower temperature is possible. As the molecule or atom is the last subdivision of matter, so is this the end of heat.

FIG. 1.

FIG. 3.

FIG. 2.

If a set of bodies in rapid motion were thrown in among a set in sluggish motion, there would be a tendency toward equalization of movement, the rapid particles would impart velocity to the sluggish ones, and would have their own motion impaired. This is what takes place with molecules. The rapidly vibrating ones, that is to say, the hot ones, tend to impart their motion, which is their heat, to more slowly moving or cooler ones. This operation is continually going on in nature. Relatively hot bodies are continually imparting their energy to cooler ones. The total amount of energy in the world never changes, but is perpetually tending toward equalization in all substances. The available energy, that which can do outside mechanical work, depends on the different temperature of things. Hence, as this difference is continually diminishing, the available energy of the universe tends toward zero or nothingness. When the time shall come when all bodies will be at the same temperature, when no chemical action can be invoked to change the temperature of any of them, work will no longer be possible. Then sun, earth, and stars, the tropics and the poles, the air on the mountain summits and in the valleys, will all be of one temperature. No rain will fall, no rivers will flow, motion and life will cease. All this is millions of years in advance of our cycle. But the important thing to remember is that in this state, when available energy will have disappeared, the total energy will be the same as now. The molecules will vibrate with the same vigor, but all at the same rate. This theory is coincident with the theory of the conservation of energy. Energy without the intervention of a supernatural power is invariable in amount, and cannot disappear. Though it is perfectly conceivable that a given body might reach the absolute zero, the world never can. Its molecules must forever vibrate while the present order of things obtains.

To account for the transmission of light through space, scientists have invented the luminiferous ether. This is assumed to be an extremely rare gas, or more than gas. It is assumed to be capable of receiving and transmitting undulatory motion. The transmission takes place at enormous speed. Within a certain range, undulations of the ether transmit light. If too rapid or too slow, they do not. These undulations may be imparted to it by the inter-molecular vibrations of any substance that is heated sufficiently. To produce white light, a composite series of many thousand varieties of undulations must be produced. If a limited number only is developed, the light will be colored.

When two molecules impinge, each one enters into its own characteristic vibration, which, if of sufficient intensity, reacts upon the ether and produces light. The molecule vibrates undisturbed, and with characteristic vibration until its next collision. During the collision it vibrates irregularly. The ratio of characteristic to forced and irregular vibrations, therefore, depends upon the ratio of path to collision. The more rarefied the gas, the more of its characteristic and less of forced vibrations will be apparent. But if condensed, the irregular vibrations will become more and more numerous. Now, white light is composite, and due to vibrations of an indefinite number of series. Monocolored light, on the other hand, is due to a series of vibrations of definite length. Therefore, as a rarefied gas in strong agitation will tend to produce simple series of vibrations, it will produce mono-colored light and, if more condensed, a more composite light. If sufficiently condensed it will produce white light, and, *a fortiori*, a liquid or solid ignited will do the same. Thus, spectrum of a gas under ordinary atmospheric pressure shows a very irregular distribution of colors, while the spectrum of a solid or liquid is continuous. Instances of the first appear in the spectra of volatilized salts, as of chloride of sodium, and of the second in ordinary flame. The production of continuous spectra from gases is hard to reach, but the light of the sun is due to ignited gases, and is white. The enormous gravitation exercised by the sun compresses the hollow sphere of gases surrounding it, and the number of collisions brought about by the heat and condensation develops an entirely irregular series of vibrations that produce white light. Spectrum analysis is based on these inter-molecular vibrations. The point to be emphasized is that each molecule vibrates through an irregular path back and forth, and in all directions colliding with other molecules; that, besides this motion, it also has its own internal or proper vibration. The first vibration it can impart to other molecules by direct contact. This means that it can heat them by conduction. The other vibration it can impart by the intermediation of the luminiferous ether. This means that it can heat by radiation.

Just as the air fills our measure of space and penetrates the pores of many bodies, so we suppose the rest of space to be filled with this ether, a far more tenuous fluid that penetrates the molecules of matter, that acts as the carrier or transferer of inter-molecular vibrations, that is to say, of radiant heat and of light. Just as far as atoms and molecules are removed from sensible mass, so far removed are the particles of the luminiferous ether from them. All I speak of it now for is to represent it to you as a species of inter-molecular atmosphere, that not only fills spaces, but penetrates molecules, just as its complement of gas fills a child's India-rubber balloon.

It is now time to say something about the possible shape of the molecule. There is a phase of motion in

a gas that possesses in the highest degree certain properties that we may suppose should be possessed by molecules. If a tube of air is bent around so as to form a ring, and the mass whirls around the annular axis thus formed, we have what is known as a vortex ring. By the higher mathematical analysis, this ring is proved to possess permanency of shape and of quantity of matter contained, incapacity for penetration or "interlinking" of another ring. It is also highly elastic. These qualities are suggestive of molecules. From these vortex rings a famous theory of the shape of molecules has been built up by Sir William Thomson. It is to the effect that the molecules have this shape. It can easily be illustrated by experiment. A smoker often discharges smoke rings from his mouth. A locomotive just starting on a still day often produces them. Sometimes they rise fifty feet into the air. I shall produce them in a simple way. A box (Fig. 2), one end of which is perforated with a circular aperture about three inches in diameter, has its top covered with a sheet of paper. It is filled with smoke or with a cloud of chloride of ammonium. The latter is produced by pouring a little concentrated muriatic acid and aqua ammonia separately into the box. Then by placing the paper cover in place, and tapping on its center, smoke rings rapidly issue from the orifice, some going ten or fifteen feet before they stop and disappear. They may be produced very beautifully from small boxes or from a lamp chimney (Fig. 3) whose lower end is closed by an elastic membrane. Tobacco smoke for the experiments may be furnished by a smoker (Fig. 4).

FIG. 4.

An idea of the probable size of molecules, and of the length of path through which they vibrate, has been derived from the consideration of the thickness of soap bubble films, from the attraction existing between plates of zinc and copper in connection with the heat of fusion of brass (See Thomson's and Tait's Physics, Appendix). From these observations the conclusion has been reached that the molecules are of such a size that if a drop of water were magnified to the size of the earth, the molecules composing it would be magnified to a size ranging between that of cricket balls and fine shot.

ANTHROPOMETRIC DESCRIPTION.

ABOUT two years ago we had occasion to explain the principles of the new anthropometric description adopted at the prefecture of police for the identification of old offenders who had declared a false civil status. At the time this article was published (August, 1883) the number of backsliders recognized by this system as having taken a false civil status during the six months of its operation had risen to eight. During the second semester of 1883, the number of recognitions rose from 8 to 43; in the first semester of 1884 there were 83, and in the second 158; and the number in the first semester of 1885 approaches 200!

These are great results when we take into consideration the fact that most of the persons recognized had changed identity only because they knew that they were "wanted" under their true name for other offenses. Under such conditions, the recognition of a backslider under a false name gives the same effective result as his direct arrest.

An exposition of these facts and of the advantages that result therefrom is necessary in order to show the interest that attaches to an extension of the method. A decisive step in this direction has just been taken by Mr. Herbette, director of the penitentiary administration, who has not hesitated to do over again on a scientific basis the descriptions in the prison registers, not only in all the prisons of France, but also those of Algeria.

To the ordinary data have been added mensurations of the length and breadth of the head, foot, and middle finger of the left hand. These indications alone would permit of distinguishing an individual among more than 3,000. The difficulty in the innovation is the learning by a large staff of a more accurate method of describing. Manuals embellished with numerous drawings have been composed as a guide for recorders, and from this we take a chapter relating to the form of the nose.

Profile and Dimensions of the Nose.—In man, the nose is the organ that helps the most to give the face of each one its peculiar character. Its varieties of (A) form and (B) dimensions exhibit an infinite number of combinations that familiar language has reduced to four or five types which are of easy recognition when their characters are well defined. Unfortunately, the intermediate forms, which are more frequent than the typical ones, do not fit well in the usual divisions. The terms which we are about to explain permit, on the contrary, of an accurate definition of every case.

A. Form of the Nose.—Let us first say a few words concerning the parts that make up the nose. The root, N, of the nose is that transverse depression which always exists, more or less pronounced, at the top of the organ, between the eyes and under the base of the forehead. The sub-nasal point, S, is the re-entrant angle that exists upon the median line where the base and upper lip meet (Fig. 2).

The apex of the nose is the point of reflexion of the lobule. The back of the nose is its profile line from its root to its apex. The lower edge or base of the nose extends from the apex to the sub-nasal part.

In the profile of the nose we distinguish (I.) its general form and (II.) the inclination of its base.

I. The general form of the back of the nose is expressed by the five following terms:

1. *Concave.*—The upper part, corresponding to the bones of the nose, descends more or less obliquely in nearly a straight line; then the lower part, corresponding to the lobule, extends outward, so that the line in general of the back of the nose presents a concave form in profile (Fig. 1).

2. *Rectilinear.*—The back of the nose describes nearly a straight line from the root to the point or apex (Fig. 2).

3. *Aquiline or Convex.*—The back of the nose describes a nearly uniform convex curve from the root to the apex (Fig. 3).

4. *Bent.*—The upper part of the bony portion exhibits a strong and short convexity, beneath which it continues, without notable inflexion, with the back of the lobule. This may be considered as a variety of the aquiline.

5. *Undulatory.*—The upper part is convex, as in the aquiline nose, but the profile of the lobule, instead of continuing this curve, as in the aquiline, or taking a rectilinear direction, as in the bent, is inflected inwardly. It results that the direction of the line is convex above and becomes concave beneath the bony portion, in order to become convex again toward the apex. It is therefore undulatory (Fig. 5).

II. The base of the nose may be horizontal or slope upward or downward (Figs. 6, 7, and 8). These modifications must be added, according to the case, to each of the five terms concave, rectilinear, aquiline, bent, and undulatory. For example, *concave-snub nose* (Fig. 9), *bent-hooked nose* (Fig. 10), *rectilinear-horizontal nose* (Fig. 8), etc.

From the fact that the simultaneous use of two terms is indispensable, it must not be concluded that each of them combines in practice with any one whatever of the other category, and in the same proportion. Certain combinations are much more frequently observed than others. The undulatory nose, for example, is very often hooked. The concave nose usually has a hooked base, while the aquiline has either a horizontal or hooked one. The rectilinear-horizontal nose constitutes the classical nose of Greek statuary, or the straight nose. Per contra, an aquiline-snub nose is exceptional, and a concave-hooked one is difficult to conceive of.

In practice, in order to render the definitions more precise, one is often led to use the modifications "slightly" and "strongly"; for example, nose *slightly aquiline*, that is, almost rectilinear, etc.

B. Dimensions.—Having spoken of the form, it remains for us to treat of that other element of all solids—the dimensions. The three dimensions of the nose are *length, breadth*, and *prominence*. The length is not, as might be supposed, reckoned upon the back of the nose, but is the line, N S, comprised between the root and sub-nasal point (Fig. 2). The breadth is the greatest transverse distance comprised between the two alæ. The prominence is the distance between the most salient point of the back and the line, N S.

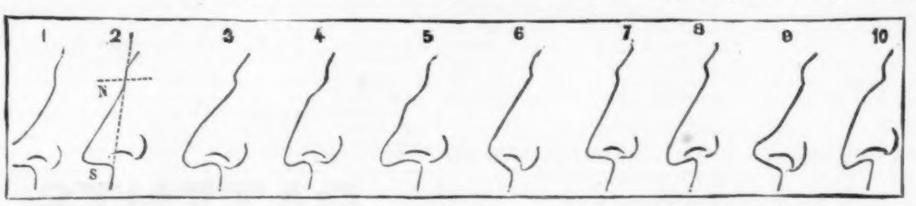
Direct mensuration of the three dimensions by means of compasses presents certain difficulties; so in the prison registers, after a description of the profile of the nose, only those dimensions are given that notably deviate from the mean in one direction or the other.

Considered with respect to its three dimensions, a nose may be *long, short, wide*, or *narrow*, and may be prominent or not. The term *flat* is reserved for noses that are wide and but slightly prominent, and *broken* for those that have been flattened by accident.

Thick, slender, pointed, are terms that are applied specially to the point of the lobule at the end of the nose.

The exclusive use of these adjectives for the special designations that are assigned to them makes it unnecessary to repeat the words *base, length, breadth*, etc., in every description.

In short, the reform that Mr. Herbette, amid so many other occupations of a high order, has taken in charge presents a certain interest from a scientific standpoint. The introduction of the four principal anthropometric mensurations into the jailer's register (a legal document prescribed by the code of criminal instruction) definitely introduces the operation of anthropometric identification into the French penitentiaries. On another hand, the laws recently enacted with a view to diminishing backsliding will certainly have, among other results, that of increasing dissimulations of identity among the incorrigible, and that, too, to a very large extent.—*La Nature.*



PROFILE OF NOSES FROM PHOTOGRAPHS AT THE PREFECTURE OF POLICE.

AN OLD BANYAN IN A BOWL.

THE curiosity in trained plants seen in our figure was brought home by Lady Brassey, after making a voyage around the world in 1876–77 in the yacht Sunbeam. It is stated to be a hundred years old. The plant and vase stand 3½ feet in height, and the plant is kept to that height by cutting back and tying. The bole from the ground to the foliage is 1 foot high, and 2 feet 9 inches in circumference, and has been used for a birdcage, the roots being tied to wires for that purpose, but now the wires are decayed with age it is no longer used for such a purpose. The plant is very healthy. We have to thank Mr. Allan, head gardener

BANYAN TRAINED.

to Sir Thomas Brassey, Normanhurst Court, for the above-mentioned particulars. The particular species of Ficus is not quite evident from the foliage merely, but it is thought to be F. vasculosa, Wall (F. Championi, Bth.). There is no specimen like it from Japan in the herbarium at Kew.—*The Gardeners' Chronicle.*

GAULTHERIA NUMMULARIOIDES.

THE Gaultherias are plants closely allied to the Pernettya and Arbutus. They belong to the natural order Ericaceæ. G. shallon, G. fragrans, and G. antipoda are strong-growing under-shrubs 3 to 6 feet high, while G. nummularifolia and G. procumbens are dwarf creeping species, covering the ground rapidly where they have a congenial soil; the latter, G. procumbens, is a pretty evergreen shrub, with ovate, leathery, dark green leaves, and with pendent, white, bell-shaped

GAULTHERIA NUMMULARIOIDES.

flowers. Its chief attraction is in autumn and winter, when its leaves change to a dull rose, and each slender stem is surmounted by beautiful scarlet fruit. The one under notice, and represented in the cut, is highly ornamental and a most useful plant; it has wiry sub-prostrate and slightly arching stems, which are clothed their entire length with alternate, roundish, Nummularia-like deep green leaves, which are silvery-green below. This feature adds greatly to the beauty of the plant, especially so when the stems are used and interspersed with cut flowers, etc. It is a most useful plant for this purpose, as it keeps fresh for weeks when placed in water. The blossoms are produced at the base of each leaf along the whole length and on the under side of the stem; in size, form, and color they

resemble those of the Lily of the Valley, though they are frequently tinged with rosy-pink. For many years this plant has been most successfully cultivated in the York nurseries, where it has been tried in various ways and used for various purposes. It forms a pleasing object when used for clothing banks on rockwork, or planted about in isolated tufts in conspicuous positions the effect is good. It has also been used with advantage in carpet bedding; where it was planted in ordinary garden soil and exposed to the full rays of the sun, it did remarkably well. Another valuable feature of this plant is its adaptability for planting in baskets for suspending from the roofs of conservatories, etc.; no plant with which I am acquainted is better suited for this purpose than this pretty Gaultheria. About a year ago one was placed in a large wire basket, and the plant is now nearly 3 feet in diameter; its running underground shoots have shot out in all directions through the apertures of the wire, over the whole surface of the basket, until it almost resembles a ball of living green. Some of the pendent shoots are nearly 18 inches long, giving the whole a most graceful and elegant appearance. I may remark that the plant is quite hardy, is evergreen, and that it thrives best in moist, sandy peat in well-drained positions. It is a native of the Himalayas.—*Richard Potter, The Gardeners' Chronicle.*

[ENGINEERING NEWS.]

DRAINAGE IN ILLINOIS.

LAND drainage on an exceptionally large scale has generally been associated with Holland and Belgium, and to a lesser degree with the fens of Lincolnshire in England. In this country it has been understood in a vague sort of a way that in Ohio, Indiana, and Illinois a very large amount of tile and open ditch drainage has been completed with a few years past, and that in part to this condition of things were due the recent flood disasters of these States. The accounts of some very large drainage enterprises in Illinois recently published in the columns of this journal have been extensively reprinted, and a widespread interest in the subject has been awakened, both on the part of the general public and the engineering profession. This interest in the subject is so great that we have been at considerable trouble and expense to collect further particulars; and with intelligent and trustworthy agents on the ground, we expect to be able to place before our readers early and accurate information of these schemes, in the States mentioned, which may be projected for the coming year. The money expenditures involved in some of the schemes already under way give them an importance rivaling that of railroad construction in the same territory.

So far as we have learned, the State of Illinois has the lead in the drainage of agricultural lands in this country, and, excepting Holland, in the world. This statement is specially true with reference to tile underdrainage, and also to the excavation of the canals used for outlets for the tile drains. We published an item recently, showing that Illinois has $10,000,000 invested in the tile industry. We will now consider only the larger outlet canals.

This class of work has been very much stimulated by the passage, three years ago, of a new drainage law, which was improved by amendments by the last Legislature.

There are now two laws, practically the same, under which this work may be done. Each provides for the election by interested land owners of three commissioners, who have sole charge. The money is raised by special taxation according to the benefit as assessed by a jury appointed for the purpose.

As far as our information goes, the first ditch was constructed near Thomasboro. It is nineteen miles long including branches, and drains, as nearly as we can determine, some 20,000 acres. It was commenced in 1881, and cost $32,000. The work was done piecemeal by inexperienced contractors, and is not as good as it might be; but it is considered to be worth all it cost. The ditch is from 6 to 16 feet wide, and 4 to 6 feet deep. The price per yard was 8, 10, and 12 cents. The cost per acre was from 50 cents to $2.50.

Within six or eight miles of this ditch, near Rantoul, another about ten miles long, and costing $35,000, has just been completed. This ditch and the land which it drains, is owned by one man, who has spent $128,000 in draining the tract. A few miles east of this a large contract has just been let, and a few miles west a still larger one is being talked of.

The largest scheme of which we have any information is the ditch between Pekin and Havana. This was commenced in 1883, and is now nearly completed. The main stem is 14½ miles long, 10 feet deep, and 30 feet wide at the top at beginning, and gradually increasing to 60 feet at top, with side slopes of 1 to 1. There are about 15 or 20 miles of laterals, 8 to 10 feet deep. Total length of ditches, 70 miles. The whole drains 47,000 acres, and the cost has been about $250,000.

The county had spent over $400,000 in trying to drain this swamp, previous to commencing this work, and had received but little or no benefit. The ditches were made with spades and scrapers, and were the best that could be made with those implements, but they were too small and soon filled up. In this kind of work the main channels must be deep to afford an outlet for the tile underdrains.

This was the first work done with a dredge, and has been so satisfactory that it may be said to have worked a revolution in such matters. The dredges, of which five have been used on this work, were constructed for the purpose by the Bucyrus Foundry and Manufacturing Co., Bucyrus, Ohio. They are boom dredges, powerfully built, but drawing less than three feet of water.

From one of a series of photographs taken on the spot, we have reproduced the accompanying sketch, which shows a Bucyrus dredge at work on an Illinois prairie. The contractors, Messrs. W. A. McGillis & Co., of Manito, Ill., have furnished the following abstract of the work of four of these dredges for two seasons up to August 1 of this year, the fifth dredge not being purchased until after that time. The prairie drained is 20 miles long and from three to five miles wide, with branches extending laterally from seven to ten miles.

"Dredge No. 1 lost one and one-half months last season (1884) before she was ready for work, and finished, during the rest of the season, 6½ miles of ditch, 45 feet on top, 35 feet on bottom (and from 8 to 10 feet deep). The same dredge had completed this season, up to August 1, 3¾ miles of the same sized ditch.

"Dredge No. 2 ran all last season, and cut 9½ miles of ditch 30 feet on top, 7 feet on the bottom, and 10 feet deep, and has finished 1 mile of the same sized ditch this season, besides cutting 5 miles of ditch, 18 feet on top, 7 feet on the bottom (and from 7 to 10 feet deep).

"Dredge No. 3 ran all of last season, making 7½ miles of ditch 30 feet on top, 7 feet on bottom, and from 7 to 13 feet deep. She is now working (August 1) on the outlet section, and is making about 3,000 feet of ditch per month, 60 feet on top, 40 feet on bottom (and from 9 to 12 feet deep).

"Dredge No. 4 has been in operation only about six weeks, and has made 1¾ miles of ditch, 16 feet on top, 7 on bottom, and 7 to 10 feet deep.

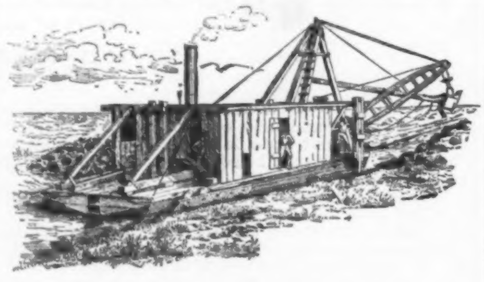
"These ditches are constructed through a variable material, muck, loam, sand, clay, quicksand, blue clay, and gravel, sometimes separate, and in all sorts of combinations. They are built with a berme of 6 to 10 feet in width, and are entirely finished by the machines; have a good slope on the banks, and regular grade in the bottom, and are entirely free from crumbs or sediment."

The fall is rarely more than three or four feet per mile, and is sometimes as small as one or one and a quarter feet per mile.

The price per yard varies from 13 to 15 cents, which is much cheaper than was bid for scraper work, as much as 19 cents having been paid for the latter.

The manufactures of the Bucyrus Foundry and Manufacturing Co. are so well known among contractors that there is nothing for us to add. These light dredges for farm and highway drainage have been an unsupplied want until met by their enterprise, which must now place them in the lead for this class of machines.

The dredges are preferred because they leave the ditch in better shape, and are able to work day and



night, in the water and in all kinds of weather, and thus complete the ditch in a reasonable time.

A large scheme is in progress in Piatt county, on which some $50,000 has already been expended, and within a very short time an additional contract has been given for increasing the width of the part already constructed, and for extending the main ditch three miles, which will ultimately be increased to eight or ten miles further. This ditch is being cut by dredges made at Bucyrus, Ohio.

A very large contract is known to be in progress in Vermilion Swamp, Ford county, but of which we have no definite information, except that a dredge is being used.

A six and one-half mile ditch is being cut south of Homer, Ill., on the great farm formerly owned by the cattle king, Sullivan. Marion Holloway, of Farmer City, Ill., has a contract for 2½ miles, which he was constructing with scrapers, but has had to suspend for the winter on account of water. This ditch will probably be extended in the near future.

A week or two since, we announced the formation of a drainage district at Pesotum, and we have just learned that steps are being taken to form another only a few miles west, with headquarters at Bement.

A project is also in progress in the neighborhood of Braidwood to drain the basin which a few years ago poured itself into the coal mine at that place with so disastrous an effect.

The works described met with great opposition at first, from the land owners, but the results have far exceeded not only their anticipations, but the expectation of the contractors themselves. These ditches actually drain, and drain thoroughly. The contractors deserve great credit for their tenacity and courage in the face of strong opposition; but they are now reaping the benefit of it. An intelligent man, a capitalist and a farmer, estimates that there are 200 miles of these large drainage canals in progress or contemplation for the immediate future, in Champaign county, Ill., alone, and that within five years 500 miles will be constructed in that State.

Here, then, is a comparatively new and promising field of enterprise. We have, as already stated, intelligent and active special agents in Illinois, Indiana, and Ohio, gathering the statistics of drainage and other improvements for this journal, and our readers may rest assured that scarcely an enterprise of any importance will escape our knowledge and speedy publication.

TRANSPLANTATION OF A RABBIT'S EYE TO A HUMAN ORBIT.

By H. W. BRADFORD, M.D.

THE patient, a man æt. 35, was the subject of atrophy of one eye, the result of an injury received during childhood. The stump having been removed, the recti muscles being divided close to the globe and held by sutures, and the optic nerve treated in the same manner—the latter suture passing as nearly as possible through the center of the nerve—a rabbit's eye, whose iris nearly matched that of the patient, was enucleated with care, the recti tendons being divided close to their insertion, the optic nerve cut at about 8 mm. from its sclerotic entrance, and both the patient's orbit and the rabbit's eye bathed in egg albumen. The nerves were then sutured together, the patient's recti fixed by sutures to the sub-conjunctival tissue, and his conjunctiva attached to a band of conjunctiva which had been left about the rabbit's cornea, the eyelids closed, dusted with iodoform, and a pad of absorbent cotton and a flannel bandage applied. The nerve suture was withdrawn on the seventh day, with those of the superior and internal recti, that attaching the external rectus having already sloughed off and allowed the muscle to contract, drawing a part of the conjunctiva with it, exposing the subjacent sclerotic. The suture of the inferior rectus sloughed away by the twelfth day. On the eighteenth day from the operation the conformation and tension were good, the cornea had become cleared sufficiently to allow the iris to be distinctly seen, and was improving; the exposed sclerotic was nearly covered, and the ocular movements, in all directions, good. Vision was not expected, and the desired cosmetic effect seemed to have been excellently secured.—*Boston Med. and Surg. Jour.*

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